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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See Advertisement, pages 29 and 77, last week.
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AUTOMATIC FEED REGULATORS,
And Auxiliary Machinery as supplied to the Admiralty. 2179

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See page 17, Nov. 4. 9108

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WANTED for any weight and size (Yorkshire District) machined if necessary.—Address, 9062, Offices of ENGINEERING.

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Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 8746
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See Advertisement page 55.

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FEED WATER HEATERS,
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CONDENSERS, AIR HEATERS,
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CARDIFF WAREHOUSE—132, BUTE ST.
BIRMINGHAM WAREHOUSE—NILE STREET, SHEEPCOTE STREET.
See Advertisement page 26. 9091

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Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4835

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CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
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9664
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Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.
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See Advertisement page 66, Nov. 4. 2403

Bull Head Rails,
Second-hand
M. R. 85 lbs. section
250 tons FOR SALE,
8,000 SLEEPERS, Chairs, Fishplates, etc.,
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For Sale, Three 250 HP.
"National" Twin Cylinder HORIZONTAL GAS ENGINES, complete with Producer Plant. £800 each.
Address, 9729, Offices of ENGINEERING.

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MOTHERWELL, SCOTLAND.
9727
See half-page Advertisement page 72, Oct. 28.

See Advt. Page 92, Nov. 4.
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Steam and Friction
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The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.

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Founded 1854 by Sir William Fairbairn.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 9310

The Bucyrus Company,

EXCAVATING AND MINING MACHINERY MAKERS

of South Milwaukee, Wisconsin, U.S.A., and formerly represented in the British Isles by Messrs. G. F. West & Co., wish to announce that they have now Opened their Own Office at

19, IDDESLEIGH HOUSE, CAXTON STREET, WESTMINSTER,

and henceforth All Communications for them should be so addressed.

9741

The Past and Present Pupils

of Messrs. Vickers, Erith, will hold their ANNUAL DINNER at the "Florence" Restaurant, Rupert Street, W., on the 10th DECEMBER. Tickets 10s. 6d. each. Those wishing to attend please communicate with J. A. I. SCRIBANTE, 26, Church Road, Erith, Kent. S 586

Correspondence Courses for

B.Sc., Inst. C.E., I. Mech. E., all ENGINEERING EXAMS. Special Courses and Single Subjects. Personal tuition.—For full particulars apply to Mr. TREVOR W. PHILLIPS, B.Sc. (Hons.). Assoc.M.Inst.C.E., M.R.S.I., etc., 8-10, Trafford Chambers, 56, South John Street, Liverpool. 9296

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., M.I.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4180 Victoria. 9814

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TENDERS.

WREXHAM AND EAST DENBIGHSHIRE WATER CO.

SUPPLY OF 12-inch DIAMETER STEEL TUBES.

The Directors invite

Tenders for the Supply and

DELIVERY of approximately 18,000 ft. of 12-in. STEEL TUBES, with Spigot and Socket ends.

Full particulars may be obtained on application to the undersigned. Sealed Tenders, endorsed "Tender for 12 in. Steel Tubes," to be delivered at the Offices of the Company, Egerton Street, Wrexham, not later than 1st December next.

The Company do not bind themselves to accept the lowest or any Tender.

FREDERICK STORR,
Engineer and Secretary.

Water Offices,
Egerton Street, Wrexham.
8th November, 1921. S 553

WREXHAM AND EAST DENBIGHSHIRE WATER CO.

12-IN. CAST IRON PIPES.

The Directors invite

Tenders for the Supply and

DELIVERY of about 800 tons of 12-in. CAST IRON PIPES and SPECIAL CASTINGS (to the British Standard Specification).

Particulars may be obtained on application to the undersigned. Sealed Tenders, endorsed "Tender for 12-in. Cast Iron Pipes," to be delivered at the Offices of the Company, Egerton Street, Wrexham, not later than 1st December next.

The Company do not bind themselves to accept the lowest or any Tender.

FREDERICK STORR,
Engineer and Secretary.

Water Offices,
Egerton Street, Wrexham.
8th November, 1921. S 552

LONDON COUNTY COUNCIL.

HAMMERSMITH STORM RELIEF SEWER.

Tenders are Invited for a

BRICK and CONCRETE SEWER of varying sizes of a total length over all of nearly 1¼ miles, together with an OUTLET into the River Thames. The work will be situated in the Metropolitan Boroughs of Kensington, Fulham and Hammersmith.

Persons desiring to Tender may obtain on and after Monday, 14th November, 1921, the Drawings, Specifications, Bills of Quantities, Form of Tender, etc., on application to the Chief Engineer at the County Hall, Spring Gardens, S.W., upon payment to the Cashier of the Council of the sum of £5. This amount will be returnable only if the tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the drawings, specification and other contract documents may be inspected at the County Hall, before the payment of the fee.

No Tender received after twelve noon on Tuesday, 29th November, 1921, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD, S 554
Clerk of the London County Council.

To Firms Wanting Work.—

QUOTATIONS are INVITED for MANUFACTURE of a SMALL REPETITION PRODUCT comprising Steel and Iron Castings, etc., and Plain Machining.

Quantity is expected to reach a high figure and depends entirely upon sales demand, and a sliding scale must provide for prices in accordance with output. Acceptance depends entirely upon terms, and the advertiser does not bind himself to accept lowest or any Tender or Quotation.

Working drawings and particulars will be sent upon receipt of application and fee of £1 1s., which fee cannot under any circumstances be returned.

Applications to—

Mr. H. George Harley, S 487
Consulting Engineer, Grand Avenue, Camberley.

CORPORATION OF GLASGOW.

GAS DEPARTMENT.

The Corporation invite

Tenders for Two Electric

LOCOMOTIVES.—Gauge 30 in.; height 68 in.; To haul 30 Tons. Particulars and form of Tender may be obtained from The General Manager, Gas Department, 45, John Street, Glasgow, on deposit of Two Guineas, which will only be returned on receipt of a *bona fide* Tender.

Tenders must be lodged with the Subscriber on or before Wednesday, 30th instant.

J. LINDSAY, Town Clerk.

City Chambers, Glasgow.
8th November, 1921. S 565

THE BENGAL AND NORTH WESTERN RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply of:—

(A) 25 BOGIE TIMBER TRUCKS, 40 ft. 6 in. long (without wheels and axles).

(B) 100 pairs of WHEELS and AXLES.

as per Specifications to be seen at the Company's Offices.

Tenders addressed to the undersigned, and marked "Tender for Timber Trucks," or as the case may be, are to be lodged not later than Noon on Monday, the 5th day of December, 1921.

For Specification (A) a fee of £1 and (B) a fee of 10s. each will be charged, which cannot, under any circumstances, be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
E. A. NEVILLE,
Managing Director.

337, Gresham House, Old Broad Street.
London, E.C. 2.
8th November, 1921. S 558

LONDON COUNTY COUNCIL.

CHARLTON STORM RELIEF SEWER.

Tenders are Invited for a

CONCRETE, REINFORCED CONCRETE and an IRON SEWER of varying sizes of a total length overall of nearly ¾ of a mile, together with an OUTLET into the River Thames. The work will be wholly situated in the Metropolitan Borough of Greenwich.

Persons desiring to Tender may obtain the Drawings, Specifications, Bills of Quantities, Form of Tender, etc., on application to the Chief Engineer at the County Hall, Spring Gardens, S.W., upon payment to the Cashier of the Council of the sum of £5. This amount will be returnable only if the tenderer shall have sent in a *bona-fide* Tender, and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the drawings, specification and other contract documents may be inspected at the County Hall before the payment of the fee.

No Tender received after twelve noon on Tuesday, 29th November, 1921, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD, S 566
Clerk of the London County Council.

METROPOLITAN WATER BOARD.

WALTON TO HONOR OAK MAIN.
Section No. 2.

TENDER FOR THE LAYING OF 48 in. MAIN, MALDEN TO CLAPHAM PARK.

The Metropolitan Water Board invite

Tenders for the Laying and

JOINTING of about 11,400 lin. yards of CAST IRON WATER MAIN, 48 inches in diameter, from Coombe Road, Malden, to Thornton Road, Clapham Park, in the Counties of Surrey and London, through public and private roads, fields, &c., together with contingent works.

Drawings, Conditions of Contract, and Specification, may be inspected without payment of fee at the Offices of the Board, Chief Engineer's Department (Room 201), New River Head, 173, Rosebery Avenue, Clerkenwell, E.C., on and after Monday, 14th November, 1921.

Forms of Tender, Conditions of Contract, Specification, Bills of Quantities, and Schedules of Prices, together with a spare copy of the Bills of Quantities and Schedules of Prices, may be obtained on and after the 14th November, 1921, from Mr. Henry B. Stilgoe, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of £20, which sum must be deposited with the Accountant to the Board at 173, Rosebery Avenue, Clerkenwell, E.C. 1, and will be returned on receipt of a *bona fide* Tender, together with all the above named documents (with the exception of the spare copy of the Bills of Quantities and Schedules of Prices, which may be retained by the Tenderer). Such payments and applications must be made between the hours of Ten a.m. and 4.30 p.m. (Saturdays Ten a.m. and Twelve noon).

Tenders, enclosed in sealed envelopes addressed to "The Clerk of the Board, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C. 1," and endorsed "Tender for Main, Walton to Honor Oak, Section No. 2," must be delivered at the Offices of the Board not later than Ten a.m. on Monday, 19th December, 1921.

The Board do not bind themselves to accept the lowest or any Tender.

W. MOON,
Clerk of the Board.

Offices of the Board,
New River Head,
173, Rosebery Avenue,
Clerkenwell, E.C. 1.
31st October, 1921. S 471

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of

the following STORES, namely:—

	Fee for Specification.
No. 1. Laminated Springs	£1
No. 2. Pig Iron	£1

Specifications and Forms of Tender may be obtained on this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Laminated Springs," or as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 22nd November, 1921.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 9th November, 1921. S 578

India Store Department,
Belvedere Road,
Lambeth, S.E. 1.
10th November, 1921.

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders for the Supply

of:—

(1). STEEL BOILER TUBES.
(2). BRAKE TRUSS BARS.

Forms of Tender may be obtained from the Director General, India Store Department, Belvedere Road, Lambeth, S.E. 1, and Tenders are to be delivered at that Office not later than Two o'clock p.m., on Thursday, the 1st December, 1921.

T. RYAN,
Director-General. S 569

ABERDEEN CORPORATION WATERWORKS. EXTENSIONS 1920.

CONTRACTS Nos. 4 & 5.—NEW AQUEDUCT.

The Town Council of Aberdeen are prepared to receive

Tenders from Competent

Persons willing to enter into Contracts for the CONSTRUCTION of (A) about ¾ mile of 4-feet CONDUIT, partly in tunnel; (B) about ¾ mile of 4-feet CONDUIT.

The Drawings may be inspected, and Specifications, Schedules of Quantities and Forms of Tender obtained on and after 21st November, 1921, on application at the Water Engineer's Office, 41½, Union Street, Aberdeen.

For each Specification of each contract a deposit of Five Pounds Sterling in cash will be required, which sum will, after a Tender has been accepted, be returned to the Tenderer, provided that he shall have sent in a *bona-fide* Tender, based on the Drawings, Specification and Schedule of Quantities provided, with the Schedule of Quantities and other Schedules fully priced out in detail and shall not have withdrawn the same. Provision is made for adjustment of the contract sum to meet alterations in the cost of labour and materials.

Tenders on the forms prescribed and enclosed in securely sealed envelopes endorsed "Tender for New Aqueduct" and addressed to the Undersigned, must be delivered not later than 9th December, 1921.

The Town Council do not bind themselves to accept the lowest or any Tender.

GEORGE MITCHELL, M.I.Mech.E.,
Water Engineer.

Water Engineer's Office,
41½ Union Street,
Aberdeen, 9th November, 1921. S 575

AUCKLAND HARBOUR BOARD.

TENDERS FOR MILD STEEL OR IRON GATES AND FENCES.

Tenders will be Received

until January 10th, 1922, for the SUPPLY of MILD STEEL or IRON GATES and FENCING for Quay Street Frontage, Auckland.

Specifications and forms of Tender may be obtained on application to the undersigned, and Drawings may be inspected at their address.

Tenders must be endorsed on envelope "tender for gates and fencing" and must be accompanied by a deposit of £50 under separate cover, both addressed to W. & A. McArthur, Ltd., the London Agents for the Auckland Harbour Board.

Tenders will be forwarded to Auckland, but the deposits will be retained in London and returned to unsuccessful Tenderers on receipt of a cable from Auckland.

The lowest or any Tender not necessarily accepted.

By Order of the Board,
W. & A. McARTHUR, LTD.,
Canberra House,
18/19, Silk Street,
Cripplegate, London, E.C. S 591

APPOINTMENTS OPEN.

CITY OF BRADFORD.

TECHNICAL COLLEGE.

Applications are Invited for

a LECTURESHIP in ELECTRICAL ENGINEERING in the College.

A salary up to £509 16s. per annum (including bonus—at present £59 16s. per annum) will be paid to a candidate of suitable qualifications and experience.

Full particulars of the appointment, and forms of application may be obtained from the Principal of the College.

Applications to be returned so as to reach me as soon as possible.

N. L. FLEMING,
Town Clerk.

Town Hall, Bradford,
2nd November, 1921. S 527

Required—Manager for

Modern Portland Cement Works in the East. Output 50,000 tons per annum with vertical kilns. Previous experience as Manager essential. Preferably under 45 and unmarried. Apply by letter, stating qualifications and full particulars of previous appointments.—Address, S 584, Offices of Engineering.

RESEARCH DEPARTMENT.

ROYAL ARSENAL, WOOLWICH.

DIRECTORATE OF BALLISTICAL RESEARCH.

ASSISTANT II.

Required, One Assistant

II. Must be an Engineer with honours degree in engineering or mechanical sciences.

Initial Salary £250 and bonus. (Total emoluments at present approximately £456).

The above post carries superannuation under a scheme similar to that of the Federated Universities.

Annual leave, six weeks.

Applications in writing, with copies of testimonials and references to any published work, should be made to the

CHIEF SUPERINTENDENT,
Research Department,
Royal Arsenal,
Woolwich,

from whom the conditions of Employment may be obtained.

S 538

ROYAL AIR FORCE.
CIVILIAN EDUCATIONAL STAFF.

Applications are Invited

for the following APPOINTMENTS in connection with the organization of educational work in Royal Air Force Units:—

Area Educational Officer at the Headquarters of:—

(a) The Inland Area (Uxbridge).
(b) The Coastal Area (London).
(c) Middle East Area (Egypt).

A Candidate to be eligible for these appointments must be a graduate of a British University, or hold an equivalent qualification, and should have had adequate teaching experience—preferably in connection with technical and adult education. Preference will be given to candidates who are familiar, as commissioned officers, with service life and organization.

The scale of salary, to which the full Civil Service bonus will be added, is:—

Basic Scale (Grade II), £250—£15—£450.
Bonus: £206 7s. 6d.—£296 7s. 6d.
Total: £456 7s. 6d.—£746 7s. 6d.

The bonus mentioned above corresponds to a cost of living index figure of 180, and is subject to an increase or decrease of 1/26 for each rise or fall of five points in the cost of living index figure.

In fixing the commencing rate of salary, previous experience in excess of five years—if of a suitable character—will be allowed to reckon up to a maximum of five increments of the scale. There will be a scheme of deferred pay in lieu of pension.

The candidate selected to fill the vacancy in Egypt will be given an acting appointment to Grade I, with pay at the minimum rate of that higher scale £460 (with present rate of bonus £746 7s. 6d.), together with a foreign service allowance of £150.

Further particulars, together with a form of application, can be obtained from the SECRETARY A.E.), AIR MINISTRY, Kingsway, W.C. 2.

S 563

A Small Company with ex-

cellent workshop, electric power and small crucible foundry in the North of England invites APPLICATIONS for POSITION of MANAGER. The basis of engagement would be moderate salary and percentage of profits. This is an opportunity for a man with initiative and resource, as he would have not only to introduce new manufactures, but also to find a market for same. In fact, he would be in a position of a man starting on his own account but with the advantage of having Factory and Capital provided.—Address, S 532, Offices of Engineering.

SOUTH STAFFORDSHIRE WATERWORKS CO.

TEMPORARY INSPECTOR OF STEEL PIPES.

The above Company require, at once, the

Services of an Inspector to

superintend the manufacture and testing of 24 in. and 18 in. Lap-welded Steel Pipes. It is expected the Contract will extend over about Twelve Months.

Applications in writing, giving age, details of experience, salary required and enclosing copies of recent testimonials, must be addressed to the undersigned.

Only applications from Inspectors who have had similar experience will be considered.

FRED J. DIXON, M.Inst.C.E.,
Engineer-in-Chief.

26A, Paradise Street,
Birmingham. S 583

Wanted, Works Manager by

Firm in the West Riding of Yorkshire employing about 80 hands. Having Foundry and Machine Shops engaged on comparatively small repetition work, in which the Castings must be accurate, and Machining done cheap for competitive trade, chiefly M.I. Pipe fittings.—Address, stating age, experience and salary, S 576, Offices of Engineering.

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REQUIRED for important Public Company in Spain. Must be British nationality, preferably with Public School education and some engineering experience. Thorough knowledge of Spanish language and Spanish business methods essential. To reside in Spain. State remuneration required and send particulars and references.—Address, S 548, Offices of Engineering.

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TRAVELLER REQUIRED with experience in Woodworking Machines. State references and terms.—Address, S 542, Offices of Engineering.

Traveller Wanted for Struc-

tural Steelwork in Midlands and Yorkshire area. Must have had experience in steel-framed buildings and structures of all kinds, and with a connection preferred. State age, experience, and salary to BOX 84, Wheeler's Advertising Agency, Manchester. S 544

RUDDER PRESSURES AND AIRSHIP "R. 38."

THE report of the Court of Inquiry into the disaster to the airship R. 38 indicates that the structure of the airship failed under the forces brought upon it when using the rudders. At the time the speed was between 45 knots and 50 knots, rudder and elevator tests were being carried out and the rudders were being moved from one side of the ship to the other, *i.e.*, a swing of the ship was obtained by putting the helm to one side and the swing was checked by reversing the helm. This is the first recorded instance of a ship's structure having failed from this particular cause, and it is desirable and useful to review the information which is available as to the forces which are brought into operation by the rudder when the helm is used. When it is remembered that the rudder has been a feature in vessels of all types and sizes for the last seven or eight centuries, it might be expected that a large amount of information relative to the forces acting on it had been accumulated. This, however, is not the case.

The force or pressure brought on the rudder when the helm is used, is principally important from the point of view of the strength of the ship both local and structural. So far as the design of the rudder itself is concerned, and also of the steering engine and gear, the twisting moment on the rudder head is more important. In one type of rudder—the "spade" type—the bending moment on the rudder stock determines the size of the latter, and to obtain this the pressure on the rudder is required, but this is the only type in which this force is necessary. The measurements of the twisting moment on the rudder stock is not difficult, and has been carried out by the French naval authorities in several types of warships and by the American, Italian and British in a few. The results of many of these experiments have been published and deserve very careful study on the part of naval architects.

The pressure on the actual rudder could be obtained from the observed twisting moments if the distance of the centre of pressure were known, but this is difficult to determine. The various aerodynamical laboratories have published many results of experiments made to determine the centre of pressure for simple shapes of plates, both plane and cambered, and inclined at different angles to the direction of motion. These, however, are but a rough guide to the position of the centre of pressure of an actual rudder which is generally of more complicated shape than those of the experimental plates, and is also affected by the streams of water deflected by the ship behind which the rudder is moving and also by the propellers immediately in front. Moreover, the twisting moments which have been observed are generally those of balanced rudders in which the centre of pressure is designedly near the axis of rotation, and any error in its determination involves a large error in the rudder pressure. It is therefore practically impossible to obtain a close estimate to the pressure acting on an actual rudder.

In the absence of definite information it is usual in calculations for the strength of rudders of ordinary ships to assume that the pressure is given by the formula $P = 1{\cdot}12\ A V^2 \sin \theta$, where the units are expressed in the foot, pound, second system, A being the area of rudder, θ the angle of helm and V the speed of the water currents meeting the rudder. V is usually assumed to be the speed of the propeller race at the full speed of the ship and θ the maximum angle of helm, usually 35 deg. to 38 deg. The formula which has been quoted has been in use for upwards of fifty years, and is based on the results of experiments made on square plates of about 3 sq. ft. area by Colonel Beaufoy, at the end of the eighteenth century.

The pressure determined from the formula used in conjunction with the position of the centre of pressure based on results of experiments on a small rectangular plate made in 1873 by Joessel, gives the twisting moment, and from this the dimensions of the rudder stock, steering gear and engine are determined. From the calculated pressure on the rudder the bending moment on any section of the ship can be readily determined, and thence the stresses on the material of the section considered. In ordinary ships the strength determined from other considerations is found amply sufficient to meet the straining actions due to using the rudder.

It is fully recognised that the pressure given by the formula quoted above is larger than is experienced in actual rudders. The latter are of much greater area than the plates used in the experiments on whose results the formula is based, and the speed is also much greater. It is known that both these differences, which cause V L of the Rayleigh law for the actual rudder to be many times greater than the value for the plates of the experiment, result in a decrease of the coefficients for resistance and pressure. The 1·12 of the formula will thus be very appreciably reduced in the actual rudder. In addition to these differences in size and speed, the rotary motion of the ship when the helm is used results in θ the angle of the formula being decreased, and as the speed of the ship is also checked V of the formula is usually diminished. Although in some rare cases difficulties have been experienced with the steering gear or steering engine, yet there is no record as to the failure of the rudder itself. This alone emphasises the opinion that calculated pressures are on the high side.

The results of observations of the twisting moments on actual rudders also lead to the same conclusion. They show that the moment is very much less than calculated. At medium speeds of ships the observed is about one-half the calculated, whilst at high speeds the proportion is one-third. Unfortunately the moment involves both pressure and the distance of the centre of pressure from the

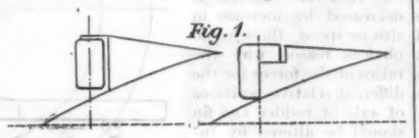


Fig. 1.

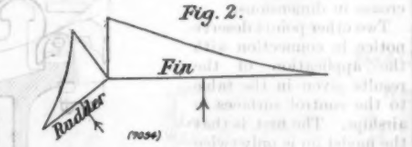


Fig. 2.

axis, and it is impossible to state if its reduction is due to a reduction in both or to one alone. It is probable that the chief reduction is in pressure, but the result is indefinite and unsatisfactory.

The absence of definite information thus forces the designers of airships to base the scantlings of the portions of the structure which have to resist the forces brought on them by the rudder, on those of previous ships which have successfully withstood such forces. Although the actual rudder pressures remain unknown their variation with speed and area is fairly definite, and thus afford a basis of comparison.

The above remarks apply to the rudder when used in the ordinary way, that is to produce a rotary motion by which a change of course of the ship is effected. If when the ship is rotating the helm is reversed so that the motion is checked, the forces operating on the rudder are increased, and with them the stresses on the ship's structure. It is a matter of common experience in light, fast vessels such as torpedo craft, that a reversal of the helm results in a much greater commotion at the stern in the form of noise and vibration than when the helm is used in the ordinary way. Some interesting particulars on the pressures operating on the rudder when the helm is reversed were published in *Schiffbau* for 1908 by Constructor Prætorious. During the turning trials of two German battleships the twisting moments on the rudder at various angles of helm were determined, first when the rudder was used in the ordinary way, and then when the ship having been given a rotary motion the helm was placed on the opposite side to check the swing. From these moments the pressures were determined by approximating to the distance of the centre of pressure from the axes and dividing the twisting moment by the distance so found. In the first ship the pressure on the rudder at 25 deg. of helm when checking the swing was three times that at the same angle when producing the swing. At 30 deg. the ratio was 3½, at 35 deg. 2·1, and at 38 deg. (the maximum angle) 1·7. In the second ship the maximum moment during checking the swing occurred at 30 deg. helm angle, and was 2½ times that at 38 deg. when producing the swing and 3·4 times that at 30 deg. Other observations showed that increases of speed of the ship slightly increased the ratios. The method of observation in these experiments was not so exact as one would wish it to be, and the ratios can only be considered as roughly approximate, but they show very clearly that reversal of helm is accompanied by very much larger forces than when the rudder is used in the ordinary way.

The results quoted above appear to be the only ones that have been published on this important matter. The rudders tested were of the type known as cruiser rudders, *i.e.*, of rectangular form with the upper forward quarter omitted. It is quite probable that in other types of ships the ratios mentioned above may be quite different and possibly greater. In the absence of definite information it will be seen how necessary it is to provide a fairly large factor of safety in the structure of a ship which is intended to be subjected to the large forces brought on her by reversal of helm at high speeds.

ENGINEERING of June 10 last, in briefly describing the chief characteristics of R. 38, referred to the fact that the rudders and elevators were of the "cruiser" type. In previous British airships these control surfaces were of simple rectangular form, rotating about an axis parallel to the leading edge and at about one-third of the smaller side of the rectangle from that edge. With the control surfaces in their normal position there were slight gaps between the leading edges of the surfaces and the trailing edges of the fins. This gap was materially increased when the surfaces were being used, giving a free passage of the air streams from one side of the fin to the other.

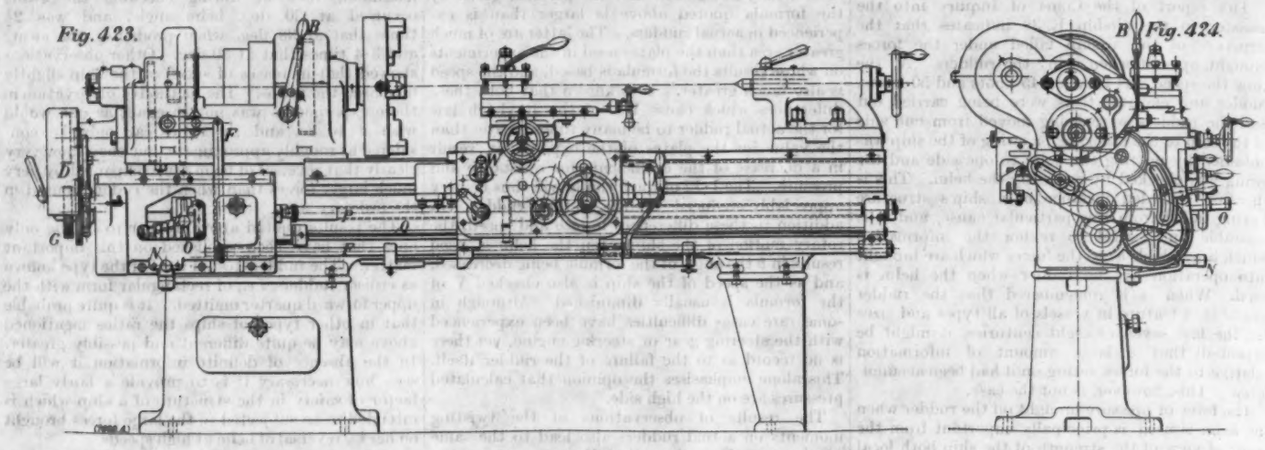
In the cruiser type of rudder the major portion of the leading edge is close to, and rotates about, the after edge of the fin, and thus there is no gap between the two by which the streams of air can pass from one side to the other. In consequence of this when the control surface is used and a pressure brought upon it, a pressure also operates on the fin and tends to turn the ship in the same direction as the pressure on the control surface. For ordinary navigation, therefore, where relatively small changes of course are effected, the cruiser type is more efficient than the simple balanced rectangle. This increased efficiency involves, however, greater controlling forces on the stern of the ship, and thus greater stresses on the structure. The two types of rudder are shown in the Fig. 1.

In a paper read before the Institution of Naval Architects in 1900, Professor Bryan dealt with this matter from the purely theoretical point of view, and principally in connection with the effect of bilge keels in minimising the rolling of ships. The "Royal Sovereign" class of battleships had not been designed with bilge keels, but were subsequently so fitted and the keels proved to be of great advantage. The results of rolling experiments carried out on the Revenge showed that if the reduction of energy of the rolling ship as measured by the observed decrement of roll, were wholly attributed to pressure on the bilge keels the coefficient of resistance for the latter must be 10 or 12 times that which had been previously considered correct. Professor Bryan showed that the bottom of the ship in the vicinity of the keels was subject to the same excesses and defects of pressure as they were, that these hull pressures assisted those on the keels in stopping rolling, and this effect in great part explained the larger resistance coefficient arrived at by supposing the pressure on the keels alone responsible for the reduction in the angle of roll.

He also pointed out that the same effect was present when a rudder hinged to the deadwood or fin of a ship was in use. The pressure on the leading edge of the rudder was also the pressure on the after edge of the fin, and that while the pressure on the rudder decreased rapidly from its leading to its trailing edge the pressure on the fin decreased less rapidly. The curves of pressure on rudder and fin were approximately as shown in Fig. 2.

The pressure on the fin assists that on the rudder

RECENT MACHINE-TOOL DEVELOPMENTS.



in turning the ship, but as the former is perpendicular to the middle line plane of the ship, whilst that on the rudder is inclined to it, the moment about the centre of gravity of the ship might very well be greater for the fin than the rudder pressure. The turning effect would thus be greater and the stresses on the structure of the ship would also be increased as compared with those due to rudder pressure alone. If there is a gap between the fore edge of rudder and after edge of fin so that a free passage of the water is from one side of the fin to the other, there is no pressure on the fin due to the rudder pressure.

Some experiments carried out at the National Physical Laboratory fully confirm these conclusions. The fin was a rectangular plate, 8 in. long and 6 in. deep, the rudder 4 in. long and 6 in. deep. Both were mounted on a frame placed in the wind channel with the fin in the direction of the wind current. The apparatus was arranged so that the total transverse force on fin and rudder was measured. Several different combinations of fin and rudder were tried. In the first the rudder was hinged to the fin, in the second the front edge of the rudder was close to the fin, but the rudder was turned about an axis one-eighth its length from the fore edge; in the third the axis was at one-third length; in the fourth at half-length; in a fifth the axis was one-third the length from the fore edge, but there was a gap of three-eighths the length between the edges of fin and rudder when the latter was at no helm. The results are as shown below, the total transverse pressure at 10 deg. of helm when the rudder is hinged to the fin, being taken as 100:—

Angle of Helm.	Total Transverse Force.				
	Axis on Fin.	Axis ⅛th from Edge.	Axis ⅓rd from Edge.	Axis ½ from Edge.	Axis ⅓rd from Edge and a Gap of ⅜ in.
deg.					
10	100	91	91	93	91
15	163	146	140	143	—
20	240	207	188	183	175
25	297	230	215	202	—
30	370	230	187	166	164
35	427	217	174	157	—

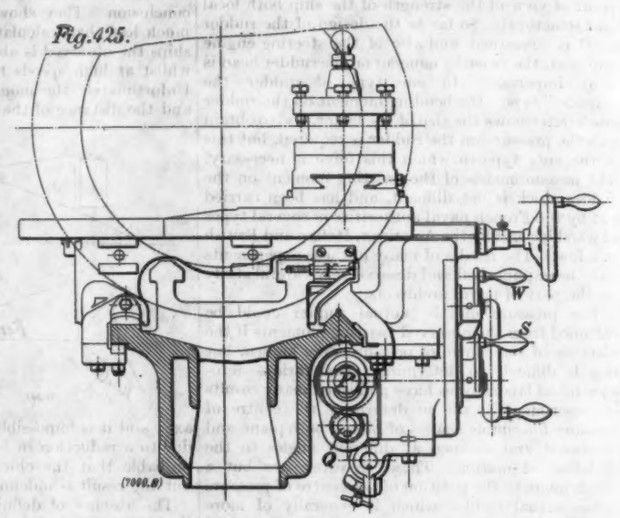
With the fin removed the transverse forces due to the rudder pressure were practically the same as those in column 4.

The results show that with the rudder hinged to the fin the transverse force increases uniformly with the helm angle, whilst with the rudder rotating about an axis one-third its length or more from the fin the maximum force occurs at 25 degrees of helm, and it is thus of little use to arrange for a larger helm angle than this. Comparing the figures in columns 2 and 4, it is seen that at 10 deg. angle of helm the transverse force is increased 10 per cent. by hinging the rudder to the fin; at 15 deg., 16; at 20 deg., 28; at 25 deg., 38; at 30 deg., 100; and at 35 deg., 150 per cent.

The areas of the model fin and rudder are very small compared with the areas in airships, but although the coefficient for transverse forces is decreased by increase in size or speed, there is no obvious reason why the ratios of the forces for the different relative positions of axis of rudder and fin should be altered by increase in dimensions.

Two other points deserve notice in connection with the application of the results given in the table to the control surfaces in airships. The first is that the model fin is only twice the area of the rudder. In airships the ratio of the areas is approximately three to one, and this difference should result in increased differences in the percentages quoted above. The second point is that the aspect ratio of the rudder is 1½, which is small compared with that actually fitted in airships. An increase in aspect ratio decreases the angle at which the maximum transverse force occurs. Thus, instead of this angle being 25 deg. for 1½ aspect ratio, it is 18 deg. for a value of 3. The effect is that for angles of helm greater than that at which the maximum force occurs the differences between the figures in columns 2 and 4 will be substantially increased. On the other hand, in Airship 38 the photographs of the ship show that about two-thirds or three-quarters of the depth of the rudders were hinged direct to the fin, and this should decrease the percentage differences as compared with the model rudder and fin. It would be interesting to see the results for model fins and rudders as actually fitted.

From the foregoing the reader will gather that our information as to the actual forces operating on a ship when its rudder is in use is extremely limited and indefinite, and that in light structures such as those of airships it is necessary to allow a more generous factor of safety for the structural portions which have to withstand these forces than for other portions of the structure whose straining action is more definitely known. It is possible to arrange the weights in an airship relative to the buoyancy, so that the shearing forces and bending moments operating on the structure as a whole may be reduced to very small amounts. If, however, more efficient control is required and especially for movements in the horizontal direction, larger forces on the structure are involved and the framing must of necessity be stronger.



Figs. 423 to 425. 200-Mm. Centre Screw Cutting Lathe; Swiss Machine Tool Works, Oerlikon, Switzerland.

In conclusion, it may be pointed out that it is from airships that more definite information as to the actual pressures on rudders and other control surfaces can be obtained, since the actual pressure at various points can be measured simultaneously without much difficulty. Certain information on this point has already been obtained, but has not yet been published.

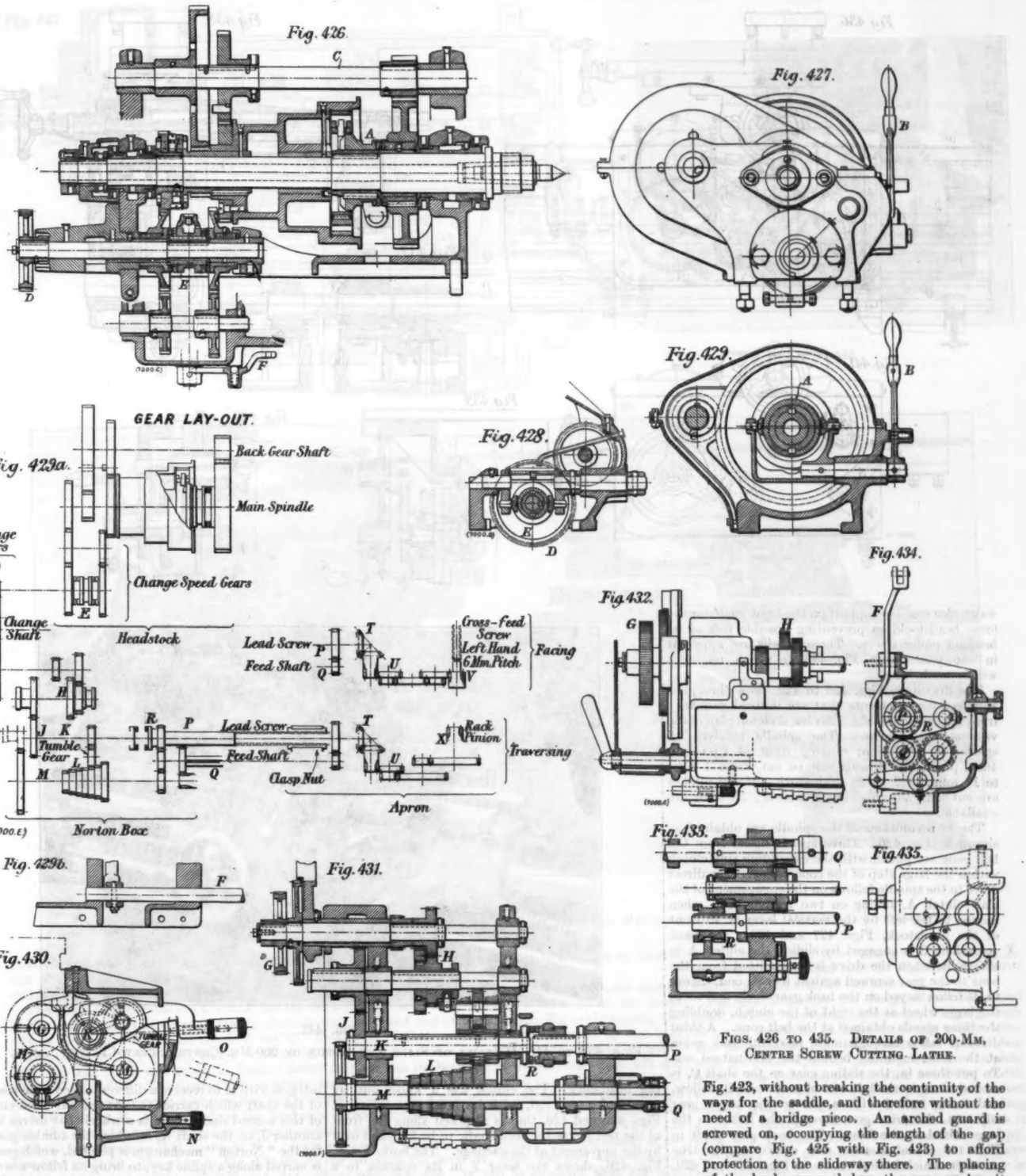
RECENT MACHINE-TOOL DEVELOPMENTS.—No. XXII.

By Joseph Horner.

The photographs and drawings accompanying this article illustrate some new lathes made by the Swiss Machine-Tool Works, Oerlikon, of Oerlikon near Zurich. Two designs are built, one with a three-stepped belt cone pulley drive, the other with a single pulley, and all-geared head. In each, there are numerous details that are worthy of attention, as being representative of the advanced views of the present time. The general outlines can be seen by the drawings, Figs. 423 and 424, giving front and end elevations respectively of the standard cone pulley design, of 200 mm. (7·87 in.) centres. This is also built of 250 mm., 300 mm. and up to 500-mm. centres.

The section through the bed and the saddle of the slide rest, Fig. 425, shows a deep bed with holes through which the cuttings fall, the metal removed receiving compensation from the deep internal ribbings. The ways for the saddle include a vee, and a flat, with gibs for both. The self-aligning

RECENT MACHINE TOOL DEVELOPMENTS.

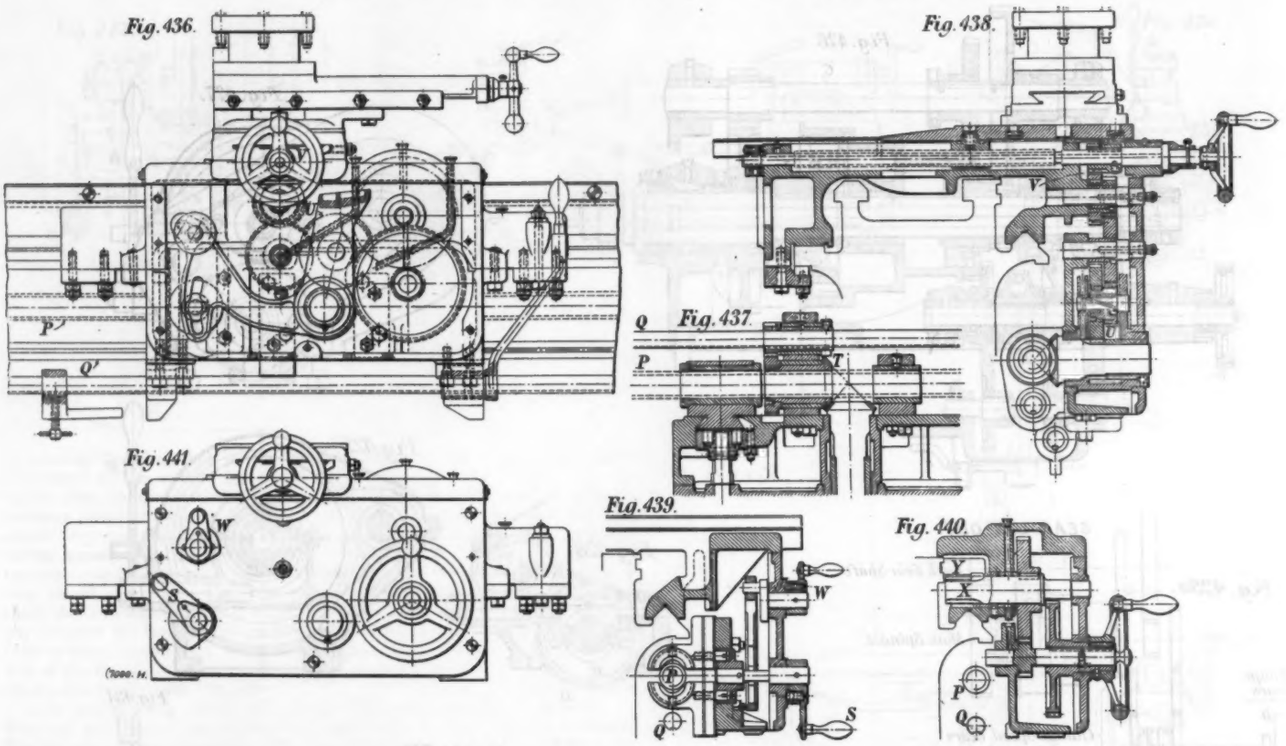


FIGS. 426 TO 435. DETAILS OF 200-MM. CENTRE SCREW CUTTING LATHE.

element is the vee, the narrow guide in effect, the edges of the carriage having clearance both at front and rear. An important feature is, that these guides for the saddle are placed considerably below the ways that receive the head and tail stocks—the double-tier design. Since the lower ways are much wider than those for the headstocks, not only is a very strong cross-section obtained, but a wide bearing surface which affords excellent support to the cutting tools when turning the largest diameters, without risk of torsion occurring.

By this arrangement, it is seen, Fig. 425, that the vee'd shear is well protected by the overhang of the rack above. Chips and soapy water, therefore, cannot fall on it to cause undue wear. The vee, in its turn, covers and protects the lead screw and the feed rod. This disposal of upper and lower ways provides a natural gap, seen in the front elevation, Fig. 423, without breaking the continuity of the ways for the saddle, and therefore without the need of a bridge piece. An arched guard is screwed on, occupying the length of the gap (compare Fig. 425 with Fig. 423) to afford protection to the slideway there. The placing of the lead screw below the way makes it possible to run the carriage over the gap without having to employ an indirect drive. The surfaces of the saddle in contact with the vee'd way are extended to right and left, Fig. 423. Here, the lower part of the saddle, made separately, is bolted to the upper through bars. These extensions prevent twisting of the saddle when screws are being cut. From Fig. 425 it will be seen that the saddle, in addition to being guided by its front and hind

RECENT MACHINE TOOL DEVELOPMENTS.



ways, also receives support on the front guide for the loose headstock, so preventing possible risk of its bending under stress. These details are apparent in the photograph, Fig. 442, to which reference will be made later.

The drawings, Figs. 426 to 429, show the speed and feed arrangements that are derived primarily from the belt cones, Fig. 429a is a skeleton plan of the various transmissions. The spindle receives 18 speeds of revolution, ranging from 14 r.p.m. to 465 r.p.m.; 28 threads can be cut, from 1 mm. to 14 mm., or 2 to 28 Whitworth. Modul pitches are cut with suitable change wheels; 28 feeds are available.

The 18 revolutions of the spindle are obtained as shown in Fig. 426. Three speeds direct from the belt cone are put in with the expanding ring clutch within the large step of the cone pulley. The direct drive to the spindle follows on the engagement of the claw clutch A, sliding on two feather keys, when moved to the left by the vertical lever B, in front of the headstock, Figs. 427 and 429. The back gear shaft C is engaged by sliding the clutch A to the right, when the drive is transmitted from the cone to the gear screwed against its rear end, thence to its fellow keyed on the back gear shaft, and so to the large wheel at the right of the clutch, doubling the three speeds obtained at the belt cone. A third drive is taken through more powerful back gears at the rear, mounted behind the first-named set. To put these in, the sliding gear on the shaft C, is moved along to the left, out of mesh with its fellow, and being locked with a pin to the larger gear adjacent, the drive goes through the latter to the large wheel at the front. The back gear shaft in Fig. 426 is, of course, not drawn in its true position, which is that shown in Figs. 427 and 429, at C. These figures also show the lower portions of the gears enclosed by the headstock casting, which forms an oil bath, and the protective coverings that encase the upper portions.

The transmission for screw cutting is as follows: It commences with the gear D, Figs. 423, 426, 428 and 429a, at the left-hand end of the headstock, on the shaft that carries the reversible clutch E, located below the spindle, its outer end being supported in the bracket bolted at the rear end of the headstock. The clutch has a knock-out by means of a stop rod, with its lever connection F, Figs. 423 and 426, that is disposed along the front of the bed below the feed shaft, to be knocked over by the movement of the carriage. The lower detail, Fig. 426, shows the lever F in its relation to a horizontal section of the front portion of the headstock. From the shaft that carries D, the drive goes through to G, with alternative transmission through the change gears adjacent to a shaft on the upper rear portion of the change box, which is shown in end view in Fig. 430. Its gears are laid out as though in one plane in Fig. 431, and a part plan is given in Fig. 432.

On the shaft that carries the wheel G, a pinion drives its fellow H, slid with a lever to cause a gear integral with H to receive a different speed from that of the shaft which carries G. At the left-hand end of this second shaft, there is a wheel that drives to another J, on the shaft K, on which the tumble gear for the "Norton" mechanism is pivoted, which gear is moved along a spline key, to bring its fellow wheel into mesh with either one of the seven nest gears L, on their shaft M. These rates are doubled by the previous transmission through either of the train of gears D to G, the swing plate for which is seen in Figs. 423 and 424, and again doubled by meshing either one of the two sliding gears H, by moving them along their shafts, to right or left with the lower lever, to engage with their fellows on the shaft driven by G. The operating levers are N, Fig. 430, which clutches the sliding gear H, and the lever O,

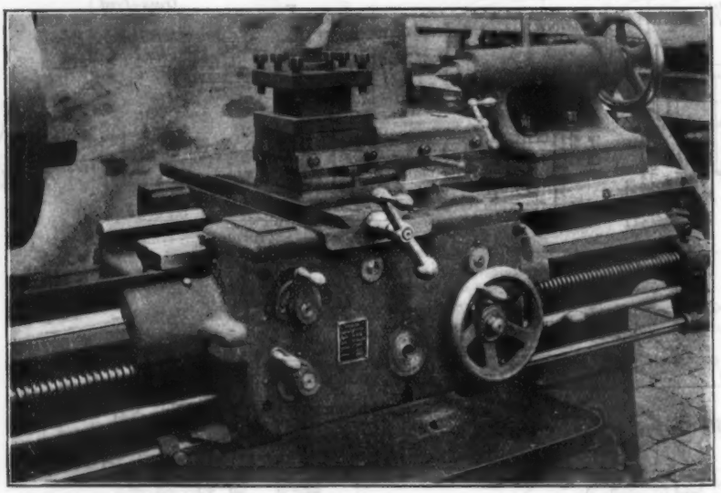
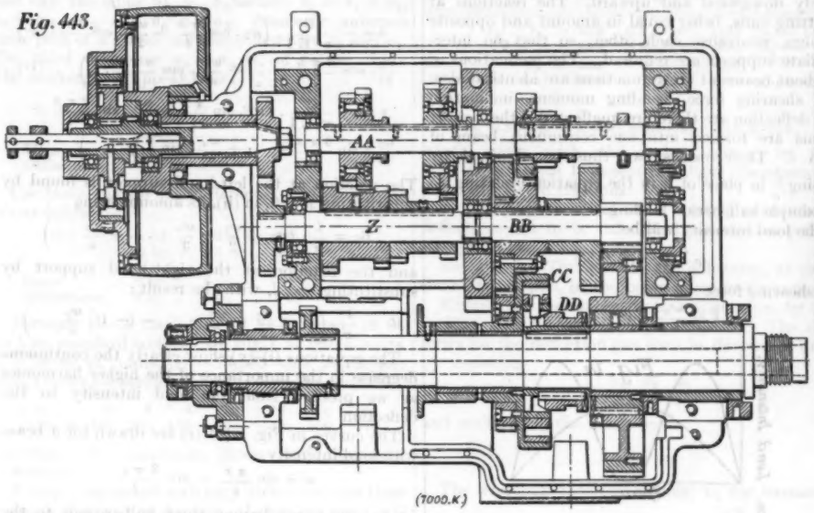


Fig. 442.

Figs. 436 to 442. Details of Slide and Apron of 200-Mm. Centre Screw-Cutting Lathe.

RECENT MACHINE-TOOL DEVELOPMENTS.

Fig. 443.



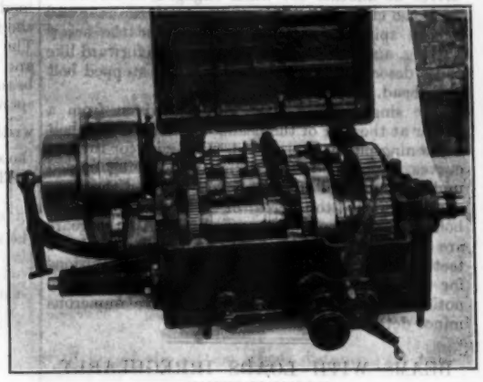


Fig. 444.

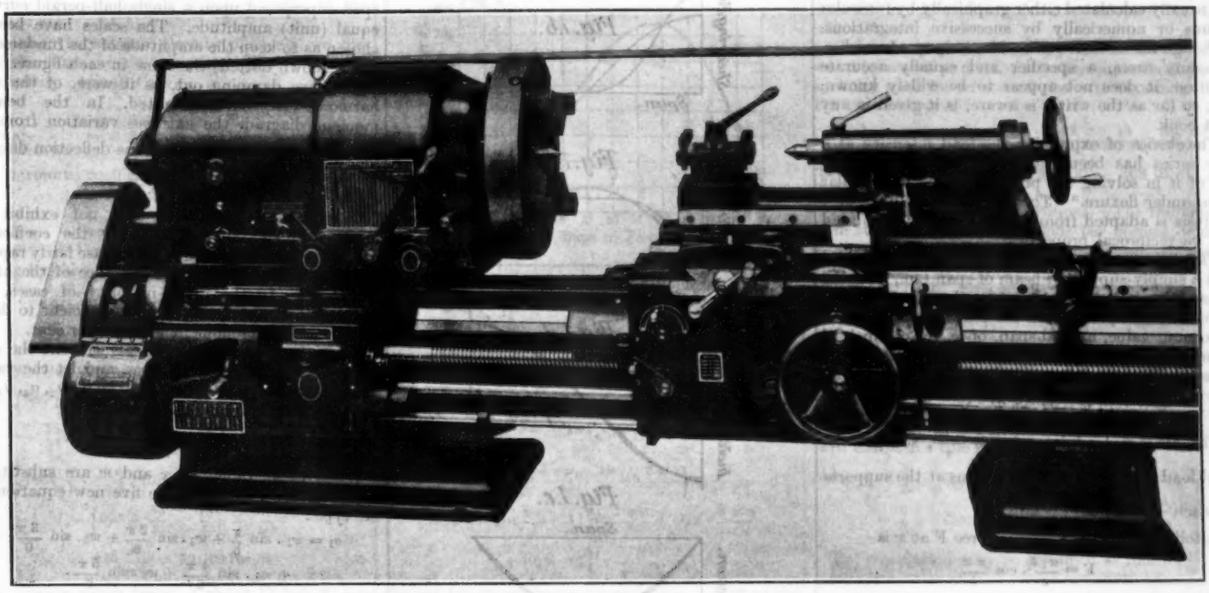


Fig. 445.

Figs. 443 to 445. Details of 200-Mm. Centre Screw-Cutting Lathe; Swiss Machine Tool Works, Oerlikon, Switzerland.

that engages the sliding tumble gears with either one of the seven on the cone L, Fig. 431, entering and locked in the notches in Figs. 423, 431 and 432.

The screw thread rates are available for the feeds to the saddle, the transmission taking place to the end of the lead screw P, or the feed rod Q. This is partly shown in Fig. 431, and is outlined in the diagram, Fig. 429*a*, and given in further detail in Figs. 433 to 435. The connection is made and broken with a sliding pin, with a spring lock moving a claw clutch R, on the end of the lead screw, Fig. 433, that engages a transmission pinion meshing with an intermediate that connects to a pinion on the feed shaft Q. The view in Fig. 433 shows the shafts and gears as though laid out flat—their true relations are given in Figs. 434 and 435. These gears are accommodated in an extension of the Norton box, provided with a door for inspection, Fig. 434.

The transmission to the slide rest is seen in Figs. 423, 425 and 436 to 441. The outline diagram in Fig. 429*a* will enable the general scheme to be grasped, and the photograph of the slide rest, Fig. 442 will be helpful. The relations of the lead screw P, and the feed shaft Q are seen in several of the views.

The half-clasp nuts, Figs. 437 and 439, are opened and closed with the lower lever S, at the front left-hand end of the carriage, Fig. 441, moving the pins in their eccentric slots. Driven by the lead screw is a mitre gear T, Fig. 437, driving its fellow that has its bearings in the carriage, Figs. 437 and 438. Solid with it is a small pinion driving a gear U, keyed with a smaller one, the latter driving, through an intermediate, a pinion, having a wheel keyed solidly with it that actuates the pinion V, on the end of the cross-feed screw. The cross-feed is put in with the lever W, Figs. 439 and 441—compare with Fig. 436. It will be observed that Fig. 438, which is a vertical section through Fig. 436, is drawn as though all these gears were in one plane, but their true relations are seen in Fig. 436.

The rack is driven from the same mitres as the screw—starting, compare with Fig. 429*a*, from the gear T on the lead screw. Thence through intermediates, the pitch circles of which are dotted in the face view of the carriage, Fig. 436, to the gear on the hand wheel shaft in Fig. 440, and a pinion on the same shaft, to a wheel, and the pinion X, meshing with the feed rack Y, Fig. 440, registered under the front edge of the bed.

Fig. 443 illustrates the design of the all-geared head, which provides 18 speeds, ranging from 14 r.p.m. to 465 r.p.m. from the single pulley drive. The photograph, Fig. 444, shows the opened box with the cover opened, and Fig. 445 the complete lathe. The drive is put in with a friction clutch at the left, Fig. 443, the operating pins being thrust radially with an overhead rod, Fig. 445, extending along the lathe, so that the attendant can move it from any position which he happens to occupy. The pulley runs on radial ball bearings. Its sleeve is extended to the right to receive the first gear in the train, which drives a similar one on a short shaft Z. On this are keyed four gears in two pairs, with which sliding gears on the shaft AA, above, can be engaged by levers outside the head, thus giving four speeds, communicated thence to two gears keyed together, sliding on the shaft AA. A radial ball bearing supports the shaft at the centre. The sliding gears drive to the short shaft BB, below, giving two changes. The driven gears are

flanked with a large wheel to the left, keyed and bolted to one of them, and with a pinion to the right, solid with the shaft. When the gear to the left is put in with an expanding ring clutch CC, it drives the spindle at one set of speeds, the pinion to the right drives at another set when engaged to its wheel with the claw clutch DD. A gear at the rear end of the spindle starts the changes for the screw cutting, and the feeds which are thenceforward like those described in connection with the stepped belt cone head.

The single pulley lathe can be driven from a motor at the rear of the headstock, for which a belt tightening pulley is provided. A device for turning curves is provided, the sliding piece being moved under the control of a guide roll between the form curves attached to the rear of the bed, and the slide bolted to the back of the carriage. All the gears are made of hardened steel, and the flanks of the teeth are corrected by grinding. The provisions for the lubrication of shafts through tubes are noticeable in the drawings, as also are numerous minor details.

BEAMS WITH LOADS IRREGULARLY DISTRIBUTED.

By T. Thompson, B.A., B.Sc.

Introduction.—The bending moments and deflections of a beam with irregularly distributed loading are usually calculated either graphically by funicular figures or numerically by successive integrations. Although the method outlined in this paper furnishes, in many cases, a speedier and equally accurate solution, it does not appear to be widely known, nor, so far as the writer is aware, is it given in any text book.

The device of expressing the load intensity as a sine series has been suggested by Saint-Venant's use of it in solving the problem of the rectangular plate under flexure.* The scheme of the harmonic analysis is adapted from Runge.† who also pointed out its reciprocal properties.

The Principal of the Proposed Method.—Consider first a simply-supported beam of span l in., carrying a load distributed according to a sine law, the span being the half-period. If the load intensity has a maximum value, at mid-span, of w_1 lb. per inch of span, then the general value of the load intensity w at x ins. from the left-hand support is given by

$$w = w_1 \cdot \sin \frac{\pi x}{l}.$$

The average load intensity is $\frac{2 w_1}{\pi}$, so that the total load is $\frac{2 w_1 l}{\pi}$ and the reactions at the supports are each $\frac{w_1 l}{\pi}$.

It follows that the shearing force F at x is

$$F = \frac{w_1 l}{\pi} \cdot \cos \frac{\pi x}{l}$$

and the bending moment M is

$$M = \frac{w_1 l^2}{\pi^2} \cdot \sin \frac{\pi x}{l}$$

If z is the deflection at x, then the curvature is

$$\frac{d^2 z}{d x^2} = \frac{M}{E \cdot I},$$

so that the inclination i (radians) of the bent beam to the initial horizontal direction is

$$i = \frac{d z}{d x} = - \frac{w_1 l^3}{\pi^3 E I} \cdot \cos \frac{\pi x}{l}$$

and the deflection itself is

$$z = - \frac{w_1 l^4}{\pi^4 E I} \cdot \sin \frac{\pi x}{l}$$

The negative sign indicates that the deflection is below the initial level. It will be omitted in numerical work.

The sine form thus persists with unchanged period in the bending moment and deflection.

From the results just obtained we can deduce corresponding equations for the case in which the span l covers several, say n, half-periods of the sine loading. In this case the beam is equivalent to n shorter beams of span $\frac{l}{n}$, each covering a half-period, the load on successive spans acting alternately downward and upward. The reactions at abutting ends, being equal in amount and opposite in sign, neutralise each other, so that no intermediate supports are required. The inclinations of the bent beams at these junctions are identical also. The shearing force, bending moment, inclination and deflection are therefore unaffected if the n short beams are formed into one continuous beam of span l. Their values can thus be obtained by writing $\frac{l}{n}$ in place of l, in the equations relating to the simple half-period loading.

The load intensity will be

$$w = w_n \cdot \sin \frac{n \pi x}{l}$$

the shearing force

$$F = \frac{w_n l}{n \pi} \cdot \cos \frac{n \pi x}{l}$$

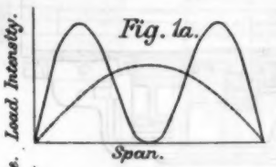


Fig. 1a.

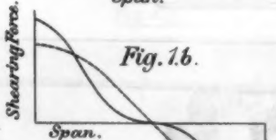


Fig. 1b.

Fig. 1c.

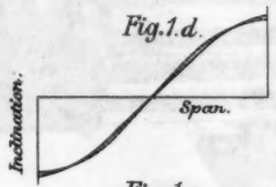


Fig. 1d.

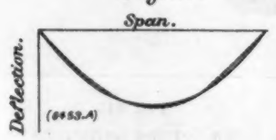


Fig. 1e.

the bending moment

$$M = \frac{w_n l^2}{n^2 \pi^2} \cdot \sin \frac{n \pi x}{l}$$

the inclination

$$i = - \frac{w_n l^3}{n^3 \pi^3 E I} \cdot \cos \frac{n \pi x}{l}$$

and the deflection

$$z = - \frac{w_n l^4}{n^4 \pi^4 E I} \cdot \sin \frac{n \pi x}{l}$$

Now any arbitrary loading may be expressed by a sine series of the form :

$$w = w_1 \cdot \sin \frac{\pi x}{l} + w_2 \cdot \sin \frac{2 \pi x}{l} + w_3 \cdot \sin \frac{3 \pi x}{l} + \ldots + w_n \cdot \sin \frac{n \pi x}{l} + \quad . \quad . \quad . \quad . \quad \text{(i)}$$

If the values of the coefficients w_1, w_2, w_3 . . . w_n, . . . can be determined, then the shearing force, the bending moment, the inclination, and the deflection can be deduced at once in the form of similar series ; for :

$$F = \frac{l}{\pi} \cdot \left(w_1 \cdot \cos \frac{\pi x}{l} + \frac{w_2}{2} \cdot \cos \frac{2 \pi x}{l} + \frac{w_3}{3} \cdot \cos \frac{3 \pi x}{l} + \ldots + \frac{w_n}{n} \cdot \cos \frac{n \pi x}{l} \ldots \right) \quad . \quad . \quad \text{(ii)}$$

$$M = \frac{l^2}{\pi^2} \cdot \left(w_1 \cdot \sin \frac{\pi x}{l} + \frac{w_2}{2^2} \cdot \sin \frac{2 \pi x}{l} + \frac{w_3}{3^2} \cdot \sin \frac{3 \pi x}{l} + \ldots + \frac{w_n}{n^2} \cdot \sin \frac{n \pi x}{l} \ldots \right) \quad . \quad . \quad \text{(iii)}$$

$$i = - \frac{l^3}{\pi^3 E I} \cdot \left(w_1 \cdot \cos \frac{\pi x}{l} + \frac{w_2}{2^3} \cdot \cos \frac{2 \pi x}{l} + \frac{w_3}{3^3} \cdot \cos \frac{3 \pi x}{l} + \ldots + \frac{w_n}{n^3} \cdot \cos \frac{n \pi x}{l} \ldots \right) \quad . \quad \text{(iv)}$$

$$z = - \frac{l^4}{\pi^4 E I} \cdot \left(w_1 \cdot \sin \frac{\pi x}{l} + \frac{w_2}{2^4} \cdot \sin \frac{2 \pi x}{l} + \frac{w_3}{3^4} \cdot \sin \frac{3 \pi x}{l} + \ldots + \frac{w_n}{n^4} \cdot \sin \frac{n \pi x}{l} \ldots \right) \quad . \quad \text{(v)}$$

The reaction at the left-hand support is found by substituting $x = 0$, in (ii), its amount being

$$R_0 = \frac{l}{\pi} \cdot \left(w_1 + \frac{w_2}{2} + \frac{w_3}{3} + \ldots + \frac{w_n}{n} \ldots \right)$$

and the reaction at the right-hand support by substituting $x = l$, with the result :

$$R_l = \frac{l}{\pi} \cdot \left(w_1 - \frac{w_2}{2} + \frac{w_3}{3} - \ldots - (-1)^n \frac{w_n}{n} \ldots \right)$$

The equations (i)–(v) show clearly the continuous decrease in the importance of the higher harmonics as we proceed from the load intensity to the deflection.

The curves in Fig. 1 (*a*)–(*e*) are drawn for a beam with load intensity

$$w = \sin \frac{\pi x}{l} + \sin \frac{3 \pi x}{l}$$

i.e., a sine curve having three half-periods to the span superposed upon a single half-period curve of equal (unit) amplitude. The scales have been so chosen as to keep the amplitude of the fundamental term (shown dotted) the same in each figure. The progressive damping out, as it were, of the third harmonic is well illustrated. In the bending moment diagram the extreme variation from the simple sine curve is $\frac{1}{9}$, and in the deflection diagram $\frac{1}{81}$ of the maximum ordinate.

This example, however, does not exhibit the method to full advantage, since the coefficients w_1, w_2, w_3, &c., will, as a rule, decrease fairly rapidly, still further reducing the importance of the higher harmonics. In the great majority of cases, five terms of the w series are amply sufficient to determine the bending moment within 1 per cent.

Determination of the Coefficients w.—Let the span be divided into six equal parts, and let the values of w at the five points of division be a_1, a_2, a_3, a_4, a_5, corresponding respectively to sections

$$x = \frac{l}{6}, \frac{2l}{6}, \frac{3l}{6}, \frac{4l}{6}, \frac{5l}{6}.$$

When these values of x and w are substituted in equation (i), they provide five new equations of the type :

$$a_1 = w_1 \cdot \sin \frac{\pi}{6} + w_2 \cdot \sin \frac{2\pi}{6} + w_3 \cdot \sin \frac{3\pi}{6} + w_4 \cdot \sin \frac{4\pi}{6} + w_5 \cdot \sin \frac{5\pi}{6}.$$

Changing the angles from radians into degrees, we obtain :

$$a_1 = w_1 \cdot \sin 30 \text{ deg.} + w_2 \cdot \sin 60 \text{ deg.} + w_3 \cdot \sin 90 \text{ deg.} + w_4 \cdot \sin 120 \text{ deg.} + w_5 \cdot \sin 150 \text{ deg.}$$

$$a_2 = w_1 \cdot \sin 60 \text{ deg.} + w_2 \cdot \sin 120 \text{ deg.} + w_3 \cdot \sin 180 \text{ deg.} + w_4 \cdot \sin 240 \text{ deg.} + w_5 \cdot \sin 300 \text{ deg.}$$

$$a_3 = w_1 \cdot \sin 90 \text{ deg.} + w_2 \cdot \sin 180 \text{ deg.} + w_3 \cdot \sin 270 \text{ deg.} + w_4 \cdot \sin 360 \text{ deg} + w_5 \cdot \sin 450 \text{ deg.}$$

$$a_4 = w_1 \cdot \sin 120 \text{ deg.} + w_2 \cdot \sin 240 \text{ deg.} + w_3 \cdot \sin 360 \text{ deg.} + w_4 \cdot \sin 480 \text{ deg.} + w_5 \cdot \sin 600 \text{ deg.}$$

$$a_5 = w_1 \cdot \sin 150 \text{ deg.} + w_2 \cdot \sin 300 \text{ deg.} + w_3 \cdot \sin 450 \text{ deg.} + w_4 \cdot \sin 600 \text{ deg.} + w_5 \cdot \sin 750 \text{ deg.}$$

Inserting the numerical values of the sines and solving for w_1, w_2, &c., we find :

$$w_1 = \frac{1}{6} \left\{ (a_1 + a_5) + 2 a_3 + \sqrt{3} \cdot (a_2 + a_4) \right\}$$

$$w_3 = \frac{1}{6} \left\{ (a_1 + a_5) + 2 a_3 - \sqrt{3} \cdot (a_2 + a_4) \right\}$$

$$w_2 = \frac{\sqrt{3}}{6} \left\{ (a_1 - a_5) + (a_2 - a_4) \right\}$$

$$w_4 = \frac{\sqrt{3}}{6} \left\{ (a_1 - a_5) - (a_2 - a_4) \right\}$$

$$w_5 = \frac{1}{3} \left\{ (a_1 + a_5) - a_3 \right\}$$

The computation is rapidly performed if the following scheme is adopted.

Write down the a's in two rows of three, a_2 being

* Saint-Venant's "Annotated Clebsch," *note du* §73.

† Runge, *Zeitschrift für Mathematik und Physik*, vol. 48, 443–456.

repeated; first row, left to right, a_1, a_2, a_3; second row, right to left, a_3, a_4, a_5; so that a_5 is under a_1, a_4 under a_2, and a_3 under a_3. Add each pair and call the sums b_1, b_2, b_3, where $b_1 = a_1 + a_5$, $b_2 = a_2 + a_4$, and $b_3 = 2\,a_3$. Similarly subtract each pair of a's and call the differences c_1 and c_2. The third difference $a_3 - a_3$ is, of course, zero. The working will appear thus :—

	a_1 ,	a_2 ,	a_3
	a_5 ,	a_4 ,	a_5
Sums . .	b_1 ,	b_2 ,	b_3
Differences .	c_1 ,	c_2	

Use these sums b and differences c to obtain the w's as follows :—

	$b_1 + b_2$,	$\sqrt{3}\,c_1$,	$2\,b_1$
	$\sqrt{3}\,b_2$,	$\sqrt{3}\,c_2$,	b_3
Sums . .	$6\,w_1$,	$6\,w_2$,	
Differences .	$6\,w_5$,	$6\,w_4$,	$6\,w_3$

Example 1.—A steel joist of 24-ft. span, 12 in. by 5 in. standard section (No. 20), I = 220 in. units, Z = 36·66 in. units, E = 13,500 tons per square inch, carries a distributed load w given by the table :

x ft.	0	4	8	12	16	20	24
w lbs./ft.	190	260	410	650	745	550	110

Calculate the maximum stress and maximum deflection.

It may be assumed with very little error that these maxima occur at mid-span. (Later examples will show that this assumption is not essential to the method.)

Following the scheme already outlined, we disregard the loads at the supports. The remaining load-intensity ordinates are :

	$a_1 = 260$	$a_2 = 410$	$a_3 = 650$
	$a_5 = 550$	$a_4 = 745$	$a_3 = 650$
Sums are	$b_1 = 810$	$b_2 = 1155$	$b_3 = 1300$
Differences are	$c_1 = -290$	$c_2 = -335$	

The harmonic coefficients are now obtained from :

	$b_1+b_3 = 2110$	$\sqrt{3}c_1 = -502$	$2b_1 = 1620$
	$\sqrt{3}b_2 = 2000$	$\sqrt{3}c_2 = -580$	$b_3 = 1300$
Sums give	$6w_1 = 4110$	$6w_2 = -1082$	
Differences give	$6w_5 = 110$	$6w_4 = 78$	$6w_3 = 320$

Dividing by the factor 6, we find

$$w = 685 \sin\frac{\pi x}{l} - 180 \sin\frac{2\pi x}{l} + 53 \sin\frac{3\pi x}{l} + 13 \sin\frac{4\pi x}{l} + 18 \sin\frac{5\pi x}{l}.$$

Equation (iii) gives

$$M = \left(685 \sin\frac{\pi x}{l} - \frac{180}{2^2}\sin\frac{2\pi x}{l} + \frac{53}{3^2}\sin\frac{3\pi x}{l} + \frac{13}{4^2}\sin\frac{4\pi x}{l} + \frac{18}{5^2}\sin\frac{5\pi x}{l}\right) \times \frac{l^2}{\pi^2}$$

At mid-span $\frac{x}{l} = \frac{1}{2}$, for which

$$M = \left(685 - \frac{53}{3^2} + \frac{18}{5^2}\right) \times \frac{l^2}{\pi^2} = 680\,\frac{l^2}{\pi^2} = 39{,}700 \text{ lbs./ft.}$$

with a corresponding stress of about 13,000 lb. per square inch or 5·8 tons per square inch.

The deflection at mid-span is by equation (v) :

$$z = \left(685 - \frac{53}{3^4} + \frac{18}{5^4}\right) \times \frac{l^4}{\pi^4\,E\,I} = 684\,\frac{l^4}{\pi^4\,E\,I} \text{ (foot units)}$$

$$= \frac{684}{12}\,\frac{l^4}{\pi^4\,E\,I} \text{ (inch units)} = 0{\cdot}607 \text{ inch, approximately.}$$

(The load-intensity graph for this example is plotted in Fig. 2. The full line is a fair curve through the points given by the table ; the dotted lines show how the sine series differs from it near the supports. The magnitude of the error due to the neglected load at the ends of the span is estimated in a subsequent paragraph.)

Reciprocal Relation between Ordinates and Harmonic Coefficients.—It may easily be verified that the same scheme which has been applied to the ordinates a to obtain the harmonic coefficients $6\,w_1$, $6\,w_2$, . . . will, if applied to the coefficients w_1, w_2, . . ., give the values of the ordinates $2\,a_1$, $2\,a_2$, . . ., the numeral factor being changed from 6 to 2.

Example 2.—To verify this theorem by applying it to the results obtained in Example 1 :—

	$w_1 = 685$	$w_2 = -180$	$w_3 = 53$		
	$w_5 = 18$	$w_4 = 13$	$w_3 = 53$		
Sums :	$b_1^1 = 703$	$b_2^1 = -167$	$b_3^1 = 106$		
Differences :	$c_1^1 = 667$	$c_2^1 = -193$			
	$b_1^1 + b_2^1 = 809$	$\sqrt{3}\,c_1^1 = 1155$	$2b_1^1 = 1406$		
	$\sqrt{3}\,b_2^1 = -289$	$\sqrt{3}\,c_2^1 = -334$	$b_3^1 = 106$		
Sums :	$2a_1 = 520$	$2a_2 = 821$			
Differences :	$2\,a_5 = 1098$	$2\,a_4 = 1489$	$2a_3 = 1300$		

Whence

$$a_1 = 260,\ a_2 = 410,\ a_3 = 650,\ a_4 = 744,\ a_5\ 549,$$

which agree with the values given in the table of Example 1, except for slight discrepancies due to neglected fractions.

This theorem is useful when bending moments or deflections are to be calculated for various points along the span.

Example 3.—To calculate the deflection, at each sixth of the span, of the beam given in Example 1.

Express the load intensity as a sine series, by the method already explained (Example 1). The sine series for the deflection can then be derived at once by replacing

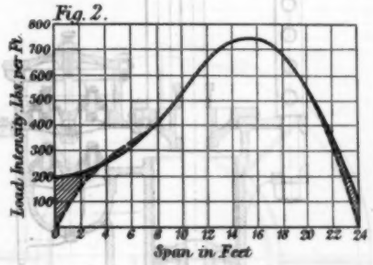
$$w_1, w_2, w_3 \ldots \text{ by } \frac{w_1}{1^4}, \frac{w_2}{2^4}, \frac{w_3}{3^4} \ldots$$

and multiplying the whole by

$$\frac{l^4}{\pi^4\,E\,I}$$

The reciprocal theorem, applied to the harmonic

Fig. 2.



coefficients of the deflection series, will then supply the required deflections. The calculation may be set out as follows :—

By Example 1 :

$$w = 685 \sin\frac{\pi x}{l} - 180 \sin\frac{2\pi x}{l} + 53 \sin\frac{3\pi x}{l} + 13 \sin\frac{4\pi x}{l} + 18 \sin\frac{5\pi x}{l}.$$

Hence :

$$z = \left(685 \sin\frac{\pi x}{l} - \frac{180}{2^4}\sin\frac{2\pi x}{l} + \frac{53}{3^4}\sin\frac{3\pi x}{l} + \frac{13}{4^4}\sin\frac{4\pi x}{l} + \frac{18}{5^4}\sin\frac{5\pi x}{l}\right) \times \frac{l^4}{\pi^4\,E\,I}$$

$$= \left\{685 \sin\frac{\pi x}{l} - 11 \sin\frac{2\pi x}{l} + (1)\sin\frac{3\pi x}{l} + (0) + (0)\right\} \times \frac{l^4}{\pi^4\,E\,I},$$

the last two terms becoming negligible. Postponing the multiplication by the factor $\frac{l^4}{\pi^4\,E\,I}$, we find by the scheme :

	685	−11	1
	0	0	1
	685	−11	2
	685	−11	
	687	1187	1370
	−19	−19	2
	668	1168	
	706	1206	1368

i.e.,

$$\text{at } x = \frac{l}{6},\ z = \frac{668}{2} \times \frac{l^4}{\pi^4\,E\,I} \text{ (foot units)}$$

$$= \frac{668}{24} \times \frac{l^4}{\pi^4\,E\,I} \text{ (inch units)}$$

$$= 668 \times 0{\cdot}000443 = 0{\cdot}296 \text{ ins.}$$

$$\text{at } x = \frac{2l}{6},\ z = 1168 \times 0{\cdot}000443 = 0{\cdot}518 \text{ in.}$$

$$\text{at } x = \frac{3l}{6},\ z = 1368 \times 0{\cdot}000443 = 0{\cdot}607 \text{ in.}$$

$$\text{at } x = \frac{4l}{6},\ z = 1206 \times 0{\cdot}000443 = 0{\cdot}534 \text{ in.}$$

$$\text{at } x = \frac{5l}{6},\ z = 706 \times 0{\cdot}000443 = 0{\cdot}312 \text{ in.}$$

Correction for Maximum Value.—In Example 1 the maximum values of the bending moment and the deflection were assumed to occur at mid-span. This is usually sufficiently correct, but a closer approximation, if desired, may be found by interpolation.

If y_2, y_3, y_4, be equidistant ordinates of a curve (strictly, of a parabola whose axis is parallel to the ordinates), having a maximum in the neighbourhood of y_3, then the maximum value will be :

$$y_3 + \frac{(y_4 - y_2)^2}{8\{2\,y_3 - (y_4 + y_2)\}},$$

occurring at the fraction

$$\frac{y_4 - y_2}{2\{2\,y_3 - (y_4 + y_2)\}}$$

of the interval between ordinates, measured from y_2 towards y_4. (If y_4 is less than y_2, this latter fraction will be negative, indicating that the measurement is from y_3 towards y_2.)

Thus the values of the deflection calculated above (Example 3) correspond to a maximum deflection

$$0{\cdot}607 + \frac{(0{\cdot}534 - 0{\cdot}518)^2}{8\{2 \times 0{\cdot}607 - (0{\cdot}534 + 0{\cdot}518)\}} = 0{\cdot}607 + 0{\cdot}0002 \text{ in.}$$

occurring at the section whose distance past mid-span is the fraction

$$\frac{(0{\cdot}534 - 0{\cdot}518)}{2\{2 \times 0{\cdot}607 - (0{\cdot}534 + 0{\cdot}518)\}}$$

of the 4-ft. interval, *i.e.*, at about 2·5 in. past mid-span. In this case the correction to be applied lies within the limits of error adopted in the calculation.

The values of the bending moments may be found by a similar method, the harmonic coefficients w_n being modified in accordance with equation (iii). The values are :—

x (ft.)	0	4	8	12	16	20	24
B.M. (lbs.-ft.)	0	18200	32200	39700	36900	22600	0

the maximum B.M. being 39,700 + 268 lb.-ft., at $x = 12{\cdot}91$ ft.

Frequency of Flexural Vibrations.—The frequency of flexural vibrations, N periods per minute, which is also the critical speed of revolution, is given approximately by

$$N = \frac{30}{\pi}\sqrt{g\,\int_0^l w\,z\,dx \div \int_0^l w\,z^2\,dx}.$$

The integrals can be readily evaluated by applying Simpson's rule to the products $w\,z$ and $w\,z^2$, calculated for each sixth of the span. If we represent $w\,z$ or $w\,z^2$ at $x = \frac{l}{6}, \frac{2\,l}{6}$, . . . by y_1, y_2, . . ., then Simpson's rule gives :

$$\text{Integral} = \frac{1}{3} \times \frac{l}{6}(y_0 + 4y_1 + 2y_2 + 4y_3 + 2y_4 + 4y_5 + y_6) = \frac{2}{3} \times \frac{l}{6}(2y_1 + y_2 + 2y_3 + y_4 + 2y_5).$$

The calculation may be arranged as follows :—

x	w	z	$w\,z$	$w\,z$ weighted	$w\,z^2$	$w\,z^2$ weighted.
$\frac{l}{6}$	260	0·296	77	154	22·8	45·6
$\frac{2l}{6}$	410	0·518	212	212	110·0	110·0
$\frac{3l}{6}$	650	0·607	395	790	239·5	479·0
$\frac{4l}{6}$	745	0·534	398	398	212·4	212·4
$\frac{5l}{6}$	550	0·312	172	344	53·5	107·0
		Totals . .	. .	1,898		954

$$N = \frac{30}{\pi}\sqrt{\frac{32{\cdot}2 \times 12 \times 1{,}898}{954}} = 265 \text{ periods per minute.}$$

Beam of Non-uniform Section.—To obtain the deflections of such a beam, it is necessary first to calculate the bending moment at each sixth of the span, using the method already explained. Each bending moment is then to be divided by the moment of inertia of the corresponding section. These quotients must then be used to determine a harmonic series of the form

$$\frac{M}{I} = A_1 \sin\frac{\pi x}{l} + A_2 \sin\frac{2\pi x}{l} + A_3 \sin\frac{3\pi x}{l} + \&c.$$

from which we derive the harmonic series for the

deflections

$$z = \frac{l^2}{\pi^2 E}\left(\frac{A_1}{1^2}\sin\frac{\pi x}{l} + \frac{A_2}{2^2}\sin\frac{2\pi x}{l} + \frac{A_3}{3^2}\sin\frac{3\pi x}{l} + \&c.\right)$$

Limitations of the Method.—An arbitrary function of x with period l can be represented exactly by a sine series only when the latter is carried to an infinite number of terms. A finite number of terms determined from an equal number of ordinates defines a continuous function which, in general, coincides with the given arbitrary function only at the selected ordinates. Appreciable errors may arise (*a*) from the arbitrary function having non-zero values at $x = 0$ and $x = l$, and also (*b*) from abrupt variations in the arbitrary function between the selected ordinates. Errors due to (*a*) may be estimated and, if appreciable, corrected. Errors due to (*b*) may be minimised by a preliminary "smoothing-out" of the given function.

Effect of Load near Supports.—It will be observed from Fig. 2 that the w curve, as given by the sine series (shown dotted in the figure), meets the true (full-line) curve nearly tangentially at $x = \frac{l}{6}$ and $x = \frac{5l}{6}$. The shaded areas which represent the disregarded load have forms intermediate between triangles and parabolæ.

The area near $x = 0$ will be $\frac{1}{12}\,a_0 l$ if triangular and $\frac{1}{18}\,a_0 l$ if parabolic. The centre of gravity will be at $x = \frac{l}{18}$ for the triangle and at $x = \frac{l}{24}$ for the parabola. Since a load W at x produces at mid-span a bending moment $\frac{1}{2}\,W x$, the load due to the neglected ordinate a_0 will produce at mid-span a bending moment whose value lies between $\frac{1}{2} \times \frac{a_0 l}{12} \times \frac{l}{18}$ and $\frac{1}{2} \times \frac{a_0 l}{18} \times \frac{l}{24}$ *i.e.*, between $\frac{a_0 l^2}{432}$ and $\frac{a_0 l^2}{864}$, the lower value being the more probable. Similar expressions apply for the ordinate a_6.

Example 4.—In the table of Example 1, $a_0 = 190$ and $a_6 = 110$, causing an additional B.M. at mid-span of between $\frac{(190 + 110) \times 24^2}{432} = 400$ lb.-ft. and half this amount, *i.e.*, 1 per cent. or less of the total.

The additional deflection due to the load near the supports may be estimated on the assumption that the B.M. at mid-span as calculated above is uniform along the whole span. The curve of deflection will be a circular arc, the deflection at mid-span being $\frac{M l^2}{8\,E\,I}$ or, assigning the maximum value to M, $\frac{(a_0 + a_6) l_4}{3456\,E\,I}$. The probable additional deflection will be only one-half of this. On this basis the addition to the deflection in Example 1 is

$$\frac{(190 + 110) \times (24 \times 12)^4}{12 \times 3456 \times 13500 \times 2240 \times 220} = 0{\cdot}0075 \text{ in.}$$

as the upper limit.

As a verification of the above reasoning, consider the case of a uniform load distribution w. The exact sine series for w is known to be

$$w = \frac{4w}{\pi}\left(\sin\frac{\pi x}{l} + \frac{1}{3}\sin\frac{3\pi x}{l} + \frac{1}{5}\sin\frac{5\pi x}{l} + \text{etc.}\right)$$

to infinity.

When we limit the series to the first five terms, we obtain by the scheme already indicated :—

	1	1	1
	1	1	1
Sums	2	2	2
Differences	0	0	
	4	0	4
	$2\sqrt{3} = 3{\cdot}464$	0	2
Sums	$6\,w_1 = 7{\cdot}464$	$6\,w_2 = 0$	
Differences	$6\,w_5 = 0{\cdot}536$	$6\,w_4 = 0$	$6\,w_3 = 2$

whence

$$w = w\left(1{\cdot}244\sin\frac{\pi x}{l} + 0{\cdot}333\sin\frac{3\pi x}{l} + 0{\cdot}089\sin\frac{5\pi x}{l}\right)$$

The maximum B.M., as given by the scheme, is therefore

$$= \frac{w l^2}{\pi^2}\left(1{\cdot}244 - \frac{0{\cdot}333}{9} + \frac{0{\cdot}089}{25}\right) = 0{\cdot}1226\,w l^2$$

and the maximum deflection

$$= \frac{w l^4}{\pi^4 E I}\left(1{\cdot}244 - \frac{0{\cdot}333}{81} + \frac{0{\cdot}089}{625}\right) = 0{\cdot}01272\,\frac{w l^4}{E I}$$

The true values are $\frac{w l^2}{8} = 0{\cdot}125\,w l^2$ for the maximum B.M. and $\frac{5}{384}\,\frac{w l^4}{E I} = 0{\cdot}01301\,\frac{w l^4}{E I}$ for the maximum deflection. These may be derived in a similar manner from the infinite (exact) sine series for w. Our previous results therefore require corrections of $0{\cdot}0024\,w l^2$ and $0{\cdot}00029\,\frac{w l^4}{E I}$ respectively. The estimated corrections were $\frac{(1 + 1)\,w l^2}{432} = 0{\cdot}0046\,w l^2$, and $\frac{(1 + 1)\,w l^4}{3456\,E I} = 0{\cdot}00058\,\frac{w l^4}{E I}$ as upper limits, with half these values as lower limits. It will be observed that the actual corrections agree remarkably well with the estimated lower limits.

(To be continued.)

DIRECT-ACTING BOILER FEED PUMP.

CONSTRUCTED BY MESSRS. ROBERT WARNER AND CO. (ENGINEERS), LIMITED.

Fig. 1.

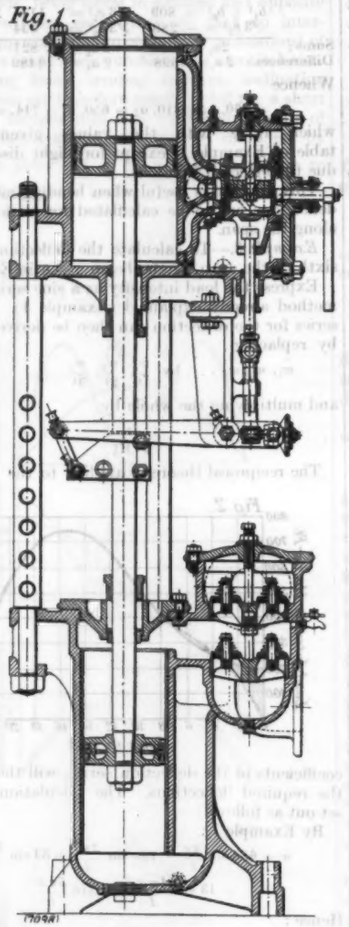


Fig. 2.

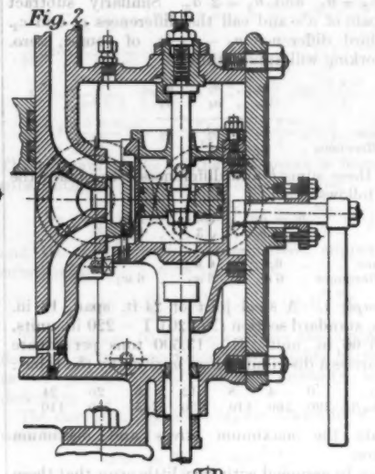
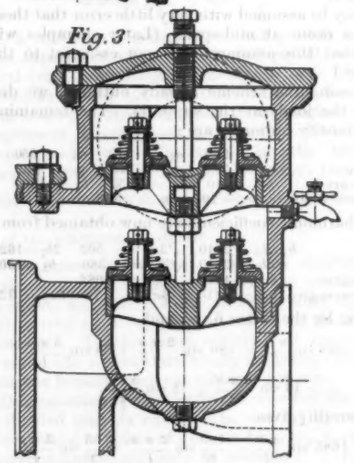


Fig. 3.



DIRECT-ACTING BOILER FEED PUMP.

An example of the latest pattern of "Anthony" boiler feed-pump is illustrated in the annexed figures. This type of direct-acting pump, which is built by Messrs. Robert Warner and Co. (Engineers), Limited, of Walton-on-the-Naze, and P. and O. House, 14–16, Cockspur-street, S.W. 1, has proved very successful during recent years, and was supplied extensively for naval services during the war. The steam end of the pump embodies special features which, it is claimed, add to the volumetric efficiency of the unit and enable it to be run at high speeds without danger. Great attention has also been paid to securing convenience of overhaul, and the special steam distribution unit can be removed, examined and replaced in from 3 minutes to 7 minutes, depending on the size of the plant. The outstanding feature of the pump is that the main steam slide valve is moved mechanically for part of its stroke, the motion being completed by steam. This combination arrangement ensures that the piston —and consequently the pump bucket—is brought to rest gradually, and without shock, at each end of the stroke, allowing the pump valves to close firmly on their seats and assisting volumetric efficiency. The valve gear also ensures the pump being entirely free from the danger of the piston striking the cylinder covers owing to the pump losing water from any cause and racing. This feature makes the "Anthony" pump very suitable for fire purposes for which it may be necessary to run at a high speed.

The general lay-out of the pump will be clearly followed from Fig. 1. The steam cylinder is carried at the top of mild-steel turned columns, the back column being arranged with a series of holes to form fulcrums for a bar when it is desired to move the pump by hand when steam is off. The steam cylinder and valve chest are a single casting, which is of simple form, so that the chest can be lagged as well as the cylinder. The piston rod is of high tensile steel, and is connected at the crosshead to the cold-rolled manganese-bronze pump rod. The pump is of the double-acting type, and the working cylinder is fitted with a renewable gun-metal liner. The water piston is of gun-metal, and is fitted with ebonite, or woodite, packing rings. The valves are of gun-metal of the solid disc type, and are well shown in the enlargement of the valve chest given in Fig. 3.

The steam distribution unit which is the special feature of the pump, is shown to an enlarged scale in Fig. 2. As will be seen, the main steam cylinder has a three-ported valve face on which an ordinary slide valve works. Behind this valve, but quite independent from it, there is a small steam cylinder, which is very clearly to be seen in Fig. 3. The piston of this cylinder is fixed, the cylinder itself moving and working on faces on either side of the main valve face. A rod with an enlarged end projects through a gland on the lower side of the valve chest. This rod, as shown in Fig. 1, is attached by lever gear to the main piston rod, a fulcrum being provided on a bracket hanging from the main casting. The rise and fall of the main piston rod transmits a reciprocating

"REGAINER" FOR COLLIERY FAN.

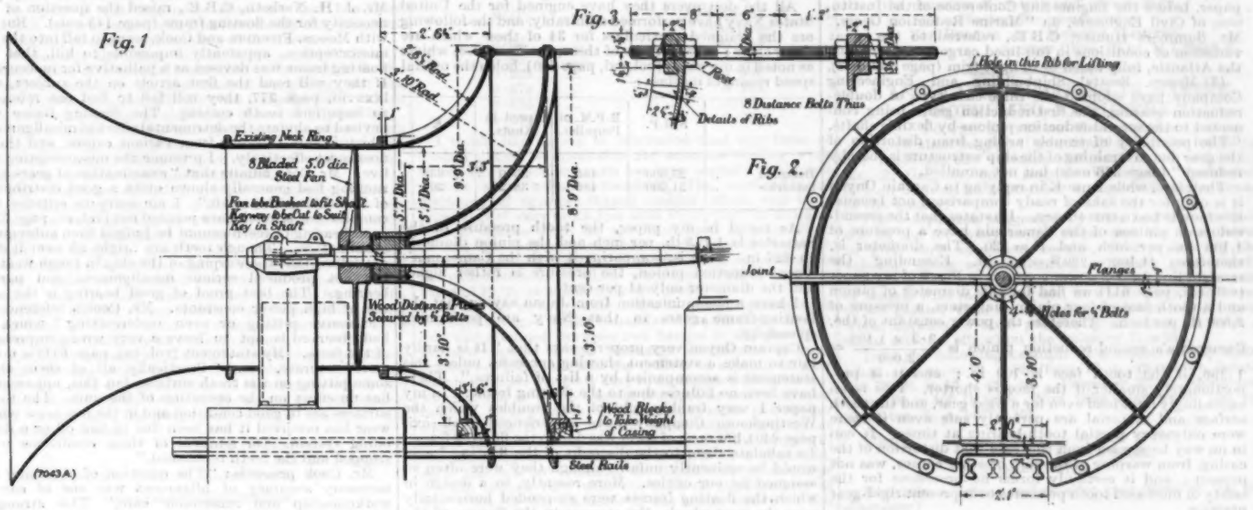
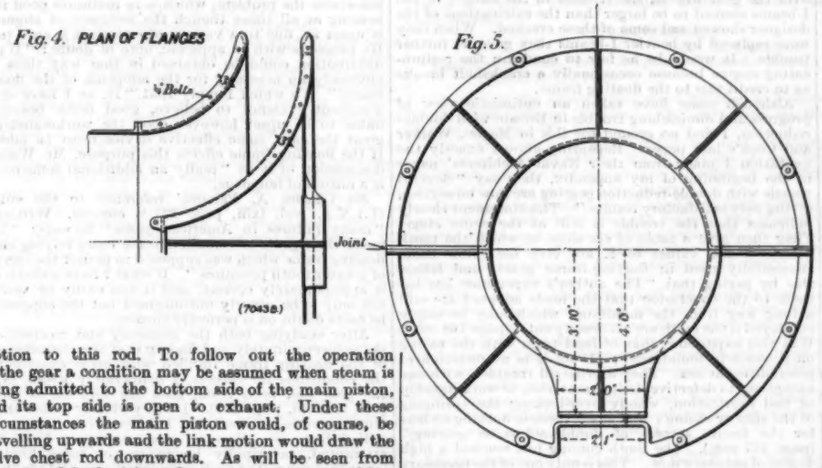


Fig. 1
Existing Neck Ring
8 Bladed 5'0" dia. Steel Fan
Fan to be Bushed to fit Shaft. Keyway to be Cut to Suit Key in Shaft
Wood Distance Pieces Secured by ¾ Bolts
Wood Blocks to Take Weight of Casing
Steel Rails
(7043A)
Fig. 3
Details of Ribs
8 Distance Bolts Thus
Fig. 2.
Joint
Flanges
Holes for ¾ Bolts



motion to this rod. To follow out the operation of the gear a condition may be assumed when steam is being admitted to the bottom side of the main piston, and its top side is open to exhaust. Under these circumstances the main piston would, of course, be travelling upwards and the link motion would draw the valve chest rod downwards. As will be seen from Figs. 1 and 2, there is at first a certain amount of lost motion, but when the enlarged end of the rod engages with the bridle at the bottom end of the small cylinder casting it will pull the cylinder downwards and with it the slide valve, the valve being engaged by a projection on the upper part of the cylinder.

There are two small ports arranged on either side of the slide valve and two corresponding small ports in the small cylinder. These ports are not shown in the figures. At the time when the main piston has nearly completed its stroke, and when the lower main steam port has been closed by the slide valve the small cylinder is pulled down into such a position that the small port on one side has passed over the edge of the main port face, and at the same moment the small port in the other side is put in direct communication with the exhaust port, the result being that live steam is admitted to the lower end of the small cylinder. This cylinder consequently shoots over the remaining part of the travel and carries the main slide valve with it. This action opens the upper main steam port to live steam and puts the lower main port to exhaust. The same sequence of operations is then repeated, the small cylinder being pushed up instead of pulled down. As will be seen from Figs. 1 and 2, auxiliary ports are formed in the main cylinder at the very end of the travel of the piston. Steam is first admitted through these ports when the piston commences its travel from either end of the cylinder. The steam connection through these ports also serves to cushion the piston at each end of its travel.

It will be clear that this gear combines advantages of a positive mechanically-driven steam-distributing arrangement allowing of a predetermined and definite cut-off as in a crank-driven pump, and at the same time by employing steam control at the end of the stroke, allows the elasticity necessary in a direct-acting arrangement. The valve gear embodying a controllable cut-off allows of economical working, and losses in the valve cylinder are cut down owing to the fact that it is always completely steam jacketted. We have already referred to the question of convenience of overhaul, and in this connection should point out that the valve unit may be completely removed by taking off the valve chest cover. Both the fixed piston rod of the small cylinder and the moving valve rod fit into forked bridles so that the unit can be drawn out sideways as soon as the cover is removed.

"REGAINER" FOR COLLIERY FAN.

In our issue of August 19 last we gave an abstract of a paper, read before the American Society of Mechanical Engineers by Mr. W. M. White, in which he described experiments on diffusers, which had led to the design of a particular type which he called the hydraucone regainer. With reference to this paper, Messrs. C. A. Parsons and Co., Limited, of the Heaton Works, Newcastle-on-Tyne, have sent us drawings of a similar type of diffuser, from which we have prepared the engravings, Figs. 1 to 6, on the present page.

Concerning this installation, Messrs. Parsons write as follows:—

"It may interest your readers to learn that a similar apparatus was designed by this company in 1903, for use in transforming velocity head into pressure head, in connection with propeller fans for colliery ventilating work. We enclose herewith a drawing, No. C 2020, showing the details of the first of these dispersers, which was installed at the Clara Vale Colliery, Ryton-on-Tyne. The ventilating fan in this case is of the propeller type 5 ft. diameter, and is coupled direct to a steam turbine of the reaction type, running at 1,500 r.p.m. The fan is capable of dealing with 120,000 cub. ft. of free air per minute and producing a suction of 2 in. W.G.

"Originally the discharge from this fan had been fitted with a bend and a pipe of the tapered Venturi type, but this was modified to the design shown on the accompanying drawing, and a marked improvement in the efficiency was shown. The disperser, as modified eighteen years ago, is still in use, and a number of others on the same line have been put into operation since the above date.

"Mr. White's paper, of course, is of very great value, owing to the thoroughness with which the author has investigated the proportions and behaviour of this apparatus."

MECHANICAL DOUBLE-REDUCTION GEARING.

To the Editor of Engineering.

Sir,—I am gratified by the remarks (page 311 *ante*) which Captain W. Onyon, R.N., M.V.O., makes on the Appendix (page 179 *ante*) to my recent paper (vol. cxi, page 609) on marine reduction gears. My reply has been slightly delayed, partly to get the fullest data from the Westinghouse Company and also in order to study carefully the recent records on gearing which have appeared in Engineering; and I extend the scope of this letter beyond the questions raised by Captain Onyon, as the whole question is of extreme importance at present.

The Appendix was written much too late to communicate it, for the discussion of Messrs. Walker and Cook's paper, to the Institution of Naval Architects, as Captain Onyon hoped I had done.

Before replying to his very proper questions it is important to remark further on the great confusion which has been injected into recent writing and thought on the subject of gearing by the general adoption of the empirical rule, $K = p\sqrt{D}$; (or, constant = tooth pressure per inch $\div \sqrt{}$ pinion diameter). In my recent, and some earlier, papers I have devoted considerable attention to this question. I have shown that the true rule for exactly similar gears is $K_1 = p/D$ and that the adoption of the "$\sqrt{D}$" rule is a sure indication of the springing of the gear casing and ship; also that the low values of K for rigid gears and the troubles which have become so prominent are very largely due to this yield. Conviction that these actions are of high importance is spreading rapidly as experience is gained. The evidence cannot be longer misread. I adduced that of Mr. W. R. L. Emmet and the detailed statement of Mr. Hadley F. Brown (Engineering, vol. cxi, page 641); and, in my appendix, the measurements by Mr. French (page 179 *ante*) of the yields of the casing, which varied from a small value in a calm to 50/1,000 in. in a heavy sea—50 times as much as would cause serious upset of tooth pressure distribution. I also noted the double test of alignment, in shop and ship, required by the British Admiralty (Engineering, vol. cxi, page 610). To these we can now add the following:—

(1) Mr. Robert Warriner in a paper read before the American Society of Naval Architects and Marine Engineers in May, and almost entirely reprinted in Engineering (vol. cxi, page 786), remarks on accuracy being essential and directs that the casings should be made so stiff that there will be no change of alignment when bolted down in the ship; also that the keelsons should be so substantial that they will contribute to the stiffness of the casing and that they be so built on to the ship's bottom that they will not be distorted by the considerable flexure of the ship produced by change of trim and action of the sea. (These conditions can be only very partially realised). He states correctly that unless alignment can be maintained within one or two thousandths of an inch there will be only partial tooth contact; that tests on land would be carried out under the best conditions with little to distort the casings or upset alignment; but that conditions at sea are entirely different and cannot be calculated, the ship's structure

altering due to change of loading and trim, or to heavy weather; finally, that gears heavily loaded wear rapidly in heavy weather.

(2) In discussion of Messrs. Walker and Cook's recent paper, before the Engineering Conference of the Institution of Civil Engineers, on "Marine Reduction Gears," Mr. Summers Hunter, C.B.E., referred to the great variation of conditions in full-lined cargo boats, crossing the Atlantic, fully laden or in light trim (page 142 *ante*).

(3) Messrs. Scotts' Shipbuilding and Engineering Company have adopted the three-case type of double-reduction gearing, the first-reduction gears being connected to the second-reduction pinions by flexible shafts. "The possibility of trouble arising from distortion of the gear due to straining of the ship's structure is thereby reduced" (page 376 *ante*) but not annulled.

Therefore, while I use K in replying to Captain Onyon it is only for the sake of ready comparison, not because it is founded on a true theory. He states that the second-reduction pinions of the Cameronia have a pressure of 1,100 lb. per inch and K = 220. The diameter is, therefore $(1{,}100 \div 220)^2 = 25$ in. Extending the straight line for 3·3 power constant in Fig. 2 of my paper (vol. cxi, page 611) we find for this diameter of pinion and a tooth face of four pinion diameters, a pressure of 2,600 lb. per inch. Therefore the power constant of the, Cameronia's second-reduction pinion is $\frac{3{\cdot}3 \times 1{,}100}{2{,}600} =$ 1·396, if the tooth face is 100 in.; and it is proportionately smaller if the face is shorter. This is an exceedingly light load even for a rigid gear, and the tooth surface and material are perfectly safe even if there were only very partial tooth-bearing at times. It can in no way be argued from this case that distortion of the casing, from warping of the ship or other causes, was not present; and it certainly forms no precedent for the safety of increased tooth pressures over present rigid-gear practice.

We both agree that the difficulties in double-reduction gears were not due to defective design; but Captain Onyon's belief that these difficulties were not due to defective material and workmanship seems to me to raise an insurmountable difficulty. If so, why did the difficulties occur only in double-reduction gears; passing over single-reduction, and almost everything in double-reduction except the low-speed pinion? Against this, I have given (vol. cxi, page 641) a perfectly simple explanation which accounts for all the facts, and gives great added probability that misalignment occurs, due to warping of the ship and casing.

Touching the inquiries which Captain Onyon makes regarding the ships equipped with floating-frame gears, I have the following information from the Westinghouse Company:—

Referring to my table of 17 ships with high coefficients, Captain Onyon asks if they have actually worked at their designed full power. My first reply was "All ships given in the table have sailed at contract speed or higher," and adding that this is also true of all the double-reduction ships the Westinghouse Company had engined. Fearing that this might apply only to a portion of the sailing time I asked for more explicit information and received the following:

"All our double-reduction gears have been installed on merchant ships in which the maximum speed is maintained practically all the time while the ship is under way. We have no records of any ships sailing under reduced speed."

It is next asked if the ships in my table are not of the small cargo carrying type. They vary considerably in displacement from small to comparatively large, as the following table shows:—

Ship.	Displacement.	Horse-Power.	Speed.	K for Second-Reduction Pinion.
	tons.		knots.	
Agawam ..	7,475	1,300	10·5	320
Auburn ..	12,450	2,500	10·0	260
Avondale ..	12,737	2,500	10·5	260
Cabegon ..	12,225	3,000	11·0	320
Coakata ..	7,475	1,500	10·5	320
Cushnet	7,475	1,500	10·5	320
Fort Pitt Bridge	7,475	1,500	10·5	320
Hisco	12,650	2,500	10·5	260
Istan	12,225	3,000	11·0	320
Ipswich	12,450	2,500	11·0	260
Jefferson Co. ..	7,475	1,500	10·5	320
Laurel	4,296	1,800	12·0	292
Mystic	12,450	2,500	11·0	260
Overbrook ..	12,737	2,500	10·5	260
Sudbury ..	10,439	2,100	11·0	296
Toledo Bridge ..	7,475	1,500	10·5	320
Wathena ..	12,225	3,000	11·0	320

Before proceeding I may say that the Westinghouse Company have equipped 227 merchant ships with double-reduction gears and one with single-reduction gears. The United States Navy have 44 ships with single-reduction gears on the main shaft and three ships with cruising gears. They have built, for the Imperial Japanese Navy, floating-frame gears, single reduction, for one ship and are at present building four large single-reduction gears for another. The Japanese Government have manufactured these gears for several ships, some of which are in commission. The Swedish Navy have two ships equipped with these gears by the Westinghouse Company.

It is suggested that some of these may belong to the large number of ships built in the States which have had the gears removed on account of trouble, and other drives substituted. I received the following:—

"The geared turbines of the S.S. Imlay were replaced with reciprocating engines. This was due to turbine trouble and to no fault of the gear." I am further assured that all these merchant ships are now in commission or ready to go in commission when those laid up have cargoes available.

All the destroyers they have engined for the United States Navy have performed admirably, and the following are the designed particulars for 34 of these which are sister ships; also, for one of these, the Satterlee, which, as noted in my paper (vol. cxi, page 640), holds the official speed record of its class:—

—	S.H.P.	R.P.M. of Propeller.	Speed in Knots.	K
Designed ..	27,000	455	35·0	338
Satterlee ..	31,200	486	38·26	367

As noted in my paper, the tooth pressure of the Satterlee is 1,175 lb. per inch and the pinion diameter 10·227 in. That is, comparing it with the Cameronia's second-reduction pinion, the pressure is rather higher and the diameter only 41 per cent.

I have a communication from Japan saying that the floating-frame gears in that Navy are performing splendidly.

Captain Onyon very properly says that "It is hardly fair to make a statement showing successes unless this statement is accompanied by a list of failures." There have been no failures due to the floating frame. In my paper I very frankly told of the troubles which the Westinghouse Company have experienced (vol. cxi, page 640), but none of them was due to the floating frame. To tabulate them to the discredit of the floating frame would be eminently unfair—though they were often so assigned by our critics. More recently, in a design in which the floating frames were suspended horizontally over the gear wheels, the stresses in the flanges of the I-beams seemed to be larger than the calculations of the designer showed and some of these cracked. When they were replaced by heavier I-beams they gave no further trouble. It would be as fair to condemn the reciprocating engine because occasionally a crankshaft breaks as to credit this to the floating frame.

Although some have taken an optimistic view of progress and diminishing trouble in Britain with double-reduction, I find no ground for this in Messrs. Walker and Cook's last paper. Repeating almost exactly the quotation I made from their Naval Architects' paper in the beginning of my appendix, they say "Several vessels with double-reduction gearing are now on service, giving very satisfactory results." This statement clearly indicates that the trouble is still at the acute stage. They then give a table of six ships in which the tooth pressures and values of K are very far below those successfully used in floating-frame gears, and follow this by saying that "The author's experience has led them to the conclusion that the loads adopted are still a long way from the maximum which may be safely employed if the teeth are accurately cut" (page 168 *ante*). Was this experience that of land tests with the casing on a concrete foundation? If so, it is no criterion of possibilities at sea. They ascribe all troubles, with one exception, to defective design, material, or workmanship or bad lubrication, wholly over-looking the springing of the ship or casing; and say "there is nothing to fear for the future success of double-reduction gearing" (page 167 *ante*). The tooth cutting has reached a high degree of accuracy now. This is only one of the necessary factors and until the high importance of elasticity, and the great redundancy of the rigid gear, are fully recognised, they will make little advance. As to the other causes—we also have had some bad material and workmanship and defective lubrication, but it has not prevented the successful use of far higher constants than the rigid gear can show.

In your editorial, vol. cxi, page 428, you say, referring to the present serious situation, "What is desirable is a free expression of experience and a complete recording and publication of full facts of performance. Along this path, and only by such means can these absorbing and highly important questions be raised from the present level of uncertainty and doubt to the realm of established experience." I offer this as my excuse for this inordinately long discussion. As you state, a number of double-reduction gear ships are sailing at a fraction of full power and thus carrying much less than the designed tooth pressures. How very small this must be if we are to accept the five ships instanced in Messrs. Walker and Cook's Naval Architects' paper (vol. cxi, page 369) as outstanding examples! The values of K for these five ships range from 195 to 238. Referring to this editorial, Mr. Cook writes (vol. cxi, page 490), apparently regarding these values as outstanding, "Even one instance of the ability of the teeth to carry the loads mentioned without undue wear should be sufficient to justify the design . . . We have given five instances. If in other cases it is found that the same load cannot be carried, clearly some detrimental causes must be at work which should be investigated and overcome." I agree that one instance should be sufficient—if all the factors are taken into account. But with a rigid gear the design and building of the ship and rigidity of the casing are vital factors which the authors continue to overlook, but which account for the very erratic performances indicated by your editorial, for the dry of shipowners for still lower tooth pressures, and for the low constants of all the five ships instanced by Messrs. Walker and Cook. The necessity for eliminating the spring of the ship and the casing, almost entirely, from the problem we clearly foresaw, and hence the floating frame was devised; and the adoption of greatly increased constants, which experience has shown can be confidently employed, is sure proof that the evil it was designed to cure is very real and also that it eliminates it very completely. The 17 examples I tabulated in my appendix could be greatly extended.

In the discussion of Messrs. Walker and Cook's paper, Mr. J. H. Narbeth, C.B.E., raised the question of the necessity for the floating frame (page 143 *ante*). But he, with Messrs. Freeman and Cook, seem to fall into the old misconception, apparently impossible to kill, that the floating frame was devised as a palliative for inaccuracy. If they will read the first article on the subject, vol. lxxxviii, page 377, they will fail to find one reference to imperfect tooth cutting. The floating frame was devised to obviate the detrimental effect of misalignment, which is sure to occur from various causes, and this it does most effectively. I presume the misconception will live. Mr. Cook admits that "examination of gears after running had generally shown quite a good distribution of load along the teeth." I am sorry to criticise this compliment, but as I have pointed out (vol. cii, page 527), good bearing of teeth cannot be judged from subsequent examination. Though teeth are bright all over it does not follow that the warping of the ship in rough weather has not produced serious misalignment and partial bearing. The best proof of good bearing is the safe use of high power constants. Mr. Cook's reference to "excessive pitting or even undercutting" which he had observed is apt to leave a very wrong impression of the facts. My statement (vol. cxi, page 641) is much more accurate, viz., "Practically all of them show some pitting on the tooth surfaces but this, apparently, has no effect on the operation of the unit. The tooth surfaces are in good condition and in the few cases where wear has occurred it has been due to bad oil or a dirty oiling system. On removal of these conditions wear stopped and the teeth repolished."

Mr. Cook proceeds: "The question of obtaining the necessary accuracy of alignment was one of careful workmanship and reasonable care." This strangely mis-states the problem, which is to maintain good tooth bearing at all times though the accuracy of alignment is upset as, due to a variety of causes, it is sure to be. He proceeds with an apparent note of doubt: "If good distribution could be obtained in that way there was obviously no necessity for the adoption of the floating frame." To which I reply that "If, as I have shown abundant evidence to believe, good tooth bearing is liable to be upset however good the workmanship or great the care, some effective device must be added." If the floating frame effects this purpose, Mr. Walker's designation of it as "really an additional refinement" is a misuse of language.

Sir Charles A. Parsons' reference to the subject (T.I.N.A., vol. lxii, page 83) is curious. Writing of "many failures in American gears" he says: "They made their gears too small, in some cases relying on the floating frame which was supposed to permit the carrying of greater tooth pressures." If what I have written here is approximately correct, and it can easily be verified, not only is he gravely misinformed but the supposition he casts doubt on is perfectly correct.

After studying both the geometry and mechanics of the subject minutely and finding that the characteristics of the floating frame fulfilled with great exactness all the conditions for success, I deliberately wrote, before the gear had been tried, that the solution is unique (vol. lxxxviii, page 379). I was perfectly aware that it must appear egotistical, but I believed it to be true and still believe so. Various other solutions have been attempted, principally by means of some kinds of laminated gears, but each overlooked essential conditions of the problem. I concluded very early that by use of the floating frame "it would be possible to raise the power constant over two, and possibly to three, times its value for a rigid gear without exceeding the same maximum intensity of stresses" (vol. ci, page 519). This, at first, must have appeared an extreme case of the optimism of inexperience. I am confident that a dispassionate discussion of the whole facts ascertainable to-day will fully bear it out. If I am not too sanguine in the passage I put in brackets, vol. cxi, page 611, the higher limit will easily be exceeded.

I am, yours faithfully,

JOHN H. MACALPINE.

5537, Hampton-street, Pittsburgh, Pa., U.S.A.,
October 10, 1921.

"ROTARY PIERCING MACHINE."

To the Editor of Engineering.

Sir,—I have to thank your correspondent, Mr. W. K. Parsonage, for the kindly appreciation of my article on the "Rotary Piercing Machine," as expressed by his letter published in your issue of October 28, and I hope that my efforts in collaboration with Major Royds, in translating the paper which appeared in *Stahl und Eisen* will encourage others among your readers to express their opinion on the theory outlined by the German writer and, if possible, bring to light any other published information which may be available on this subject. Generally I am entirely in agreement with Mr. Parsonage in his criticism of the theory, and I certainly do not believe that the hole formation actually occurs in the manner illustrated by Fig. 14, in fact, as mentioned by your correspondent, I definitely expressed this doubt on page 527, at the same time, the German author does not necessarily imply that the angle of twist is the *cause* of the hollow forming power of the rolls, but that it is a "measure" of that power, and without agreeing with all the steps in the very ingenious analysis put forward, the value of the angle of twist calculated in the matter described does appear to provide an indication of the probable piercing effect.

Fig. 17 can also scarcely be accepted as representing the actual effect of the rolls on the billet; the original

article mentions that no positive proof has been obtained of the assumed fibre structure and that this was deduced from the supposed action of the rolls in an ordinary mill, as illustrated in Fig. 16.

In spite of the statement that this last has been proved, experiments which I have recently carried out on rolling fail to show such bending of the fibres.

As regards the shape of the billet at the "throat" of the pass, it is certainly assumed to be circular in the analysis, probably for the sake of simplicity, but the later figures, 12A and 13, show an irregular form, which approximates to the oval section observed in practice.

I am inclined to think that there is not nearly so much twisting action as is generally considered to occur, and that the harmful effect of such twisting as does exist, has hitherto been very much exaggerated.

The displacement of material necessarily takes a spiral direction, but it is difficult to see that this can injure in any way metal which is in a heated plastic condition. From results obtained from modern piercing plant, working on good quality homogeneous metal, I have failed to detect any sign of damage to the structure. Poor quality or laminated steel will of course show up badly, and for this reason tubes finished from shells produced by the rotary piercer, are necessarily sound and may be relied upon to withstand as severe tests as will those made by any other method.

As Mr. Parsonage says, a really convincing explanation of the piercing action has yet to be published, and I hope that the study of the analysis of that action which you have allowed me to bring to the notice of your readers will assist other investigators in their study of this interesting process.

Yours faithfully,
C. E. Davies.

Lynton Works, Bedford, November 2, 1921.

NAPIER'S BONES.

To the Editor of Engineering.

Sir,—With reference to your paragraph in the issue of the 28th ult. (page 601) regarding our "Wee" Arithmetical Slips we should like to make a few observations.

You state Pepys did not learn the multiplication table till quite late in life, and you refer to the *improved* methods, *i.e.*, the multiplication table, which rendered the use of Napier's Bones unnecessary.

Now we think most people will agree with us that the present system of teaching arithmetic does not encourage the use of the reasoning faculties. The multiplication table teaches nothing at all, whereas Napier's method of calculating any arithmetical problem seems to us extremely interesting. From an educational point of view the use of these should be taught in schools. We believe also it is of value in many cases where approximate figures will not serve the purpose in view, and the method is almost as rapid as logarithms, and of course dead accurate. The arithmetic slips which we publish are a modification of Napier's Bones. With the actual bones almost any calculation could be done including square and cube roots, and many things which our "slips" do not tackle, our chief object being the educational one.

Everyone knows Napier was the inventor of logarithms, and "Napier's Analogies" in spherical trigonometry, but it is not generally known he had great mechanical ingenuity.

The use of the "tank" in warfare was apparently well known to Napier who is credited with having invented an iron shield on wheels, loopholed, so that it could be used in attacking an enemy. In addition he experimented with long-range artillery, and is said to have destroyed cattle a long way off.

Yours, &c.,
Bowman and Murdoch.

99, Shoe-lane, E.C. 4.

[We did not state that the multiplication table rendered Napier's Bones unnecessary, but that their popularity declined.—Ed.E.]

"AIR GAUGING BY NOZZLES."

To the Editor of Engineering.

Sir,—My attention has been called to an article in your issue of October 14, in which the test on a "Belliss" air compressor is described. In that article it is stated that "The formula used to calculate the air delivered was that given in the Proceedings of the Institution of Civil Engineers, 1916–17, in the paper entitled 'The Commercial Metering of Air, Gas and Steam,' by John Lawrence Hodgson, B.Sc. The orifice used, and the formula used for calculating the air delivered are similar to those in use on the Rand, for the buying and selling of large quantities of compressed air, and the results may be considered as embodying the best possible accuracy under ordinary testing conditions."

I wish to point out that the statements in the paragraphs quoted above are incorrect. The formula given does not allow for the velocity of the air upstream of the orifice (*i.e.*, the terms involving the ratio of the area of the orifice to the area of the main are omitted), whereas all the formulæ given in the paper referred to make this allowance. See especially formula 16, page 150 of vol. cciv of the Proceedings of the Institution of Civil Engineers.

The orifice shown in your Figs. 24 and 25 (Plate XXXI) is not similar to those in use on the Rand "for the buying and selling of large quantities of compressed air." The purchasing companies measure their air through "Gate" meters (which have no fixed orifice), while the selling company sell the air through Venturi tubes which have an average coefficient of 0·985 for the range of flow over which they are used.

It is perhaps not generally known that the coefficient of discharge of a conical nozzle, as illustrated in your Figs. 24 and 25, varies considerably with the ratio of P_2/P_1. For instance, a typical test of such a nozzle is as follows:—

P_2/P_1.	Coefficient of Discharge.
0·98	0·886
0·96	0·896
0·925	0·906
0·875	0·914
0·825	0·924
0·775	0·931

I would like to say in conclusion that any form of shaped nozzle is unsuitable for accurate testing work unless the particular nozzle has been actually calibrated against some reliable standard. The coefficients of discharge of trumpet-shaped nozzles which end in a parallel part vary much less with P_2/P_1 than do those of conical nozzles such as are illustrated in your Figs. 24 and 25; but even so, their coefficients of discharge may be anything between 0·95 and unity, depending on the exact contour to which they are finished, and the value of P_2/P_1 at which they are used.

By far the most reliable orifice to use for testing work is a square edged orifice* chamfered on the down-stream side and clamped between two flanges in the pipe line. Reliable figures of the discharge coefficients of such orifices are available, and the orifices on account of their simple form are perfectly easy to reproduce with accuracy, which is not so in the case of trumpet or conical-shaped nozzles. It is possible, for instance, to make two *similar* square-edged orifices, one of them being many times larger than the other, whose coefficient of discharge will not differ by more than 1 or 2 parts in a thousand. As is the case with nozzles, the coefficients of discharge of such orifices vary with the ratio of the diameter of the orifice to the diameter of the main, and with the value of P_2/P_1. These variations must, of course, be allowed for.

Yours faithfully,
John L. Hodgson.

Eggington House, near Leighton Buzzard, Beds., November 2, 1921.

[A copy of the above letter was forwarded to Messrs. Belliss and Morcom, Limited, who have sent us the following reply.—Ed.E.]

Sir,—We have your letter dated 5th inst. enclosing proof of letter received from Mr. J. L. Hodgson, and beg to thank you for the opportunity afforded of replying to it in the same issue of your paper.

The article in question would have been more correctly worded if it had stated that the formula was that used on the Rand, and similar to that given in Mr. Hodgson's paper referred to, instead of the other way about. The paragraph he specially takes exception to would have been better as follows:—

"The shape of the orifice and the formula used for calculating the air delivered are similar to those in use *for testing air compressors* on the Rand where exact measurements are necessary for the buying and selling of compressed air, and the results may be considered as embodying the best possible accuracy under ordinary testing conditions."

The formula as received by us from the Rand in connection with the test of the compressor the results of which were given, was as follows:—

$$\text{Lb. per second} = C\,A\,(2\,g/R)^{\frac{1}{2}}\,(h\,P_2/T_1)^{\frac{1}{2}}\,(1 - h/28\,P_2)$$

exactly as in your article. It is true that as pointed out by Mr. Hodgson, this formula omits the correction for the velocity up-stream of the orifice, but no doubt it was advisedly omitted by the authorities on the Rand, as with the proportions of orifice and pipe ordinarily used in testing with a shaped orifice it makes such a slight difference—a difference, in fact, which would be far outweighed by ordinary observational errors. In the case in question it would have made a difference of one-fifth of 1 per cent., which we may say would have been in our favour.

Concerning the statement that the orifice shown in Figs. 24 and 25 (Plate XXXI) is not in the least similar to those in use on the Rand, &c., we can only say that it is an exact reproduction of the drawing sent us of one of the nozzles used on the test of the compressor there, the results of which are given, and that this nozzle was used in series with three similar nozzles, all of which were calibrated on the standard reciprocating meter at Ferreira Deep, the coefficients thus determined being as follows:—

RM. 2	0·9818
RM. 1	0·9781
RM. 0	0·9978
RM. 00	0·9922

The mean of these coefficients is 0·9875, which we think disposes of Mr. Hodgson's statement that the coefficient for this type of nozzle should have been 0·895.

We note Mr. Hodgson expresses his preference for a square-edged orifice rather than a shaped nozzle. This is a matter of opinion. There is a good deal to be said both ways, and we have letters from recognised authorities on the Rand expressing a preference for the shaped nozzle. In fact, the four shaped nozzles in series used were stated to be the standard there, presumably for similar tests. We ourselves expressed a preference for a square-edged orifice, and it was agreed that such an orifice should also be used in series with the others. This nozzle gave a result agreeing within 1 per cent. of the mean of the other four.

On the whole, we think you will conclude that there is nothing seriously wrong with the information supplied. Engineering firms just now are more concerned with the broad facts arising from the present period of unparalleled depression and with the struggle for existence, than the minutiæ of testing and phraseology.

We are, Sir, yours truly,
For Belliss and Morcom, Limited,
Albert Chas. Pain, M.I.Mech.E.

* See Fig. 11, page 121, of vol. cciv, of the Proceedings of the Institution of Civil Engineers.

"ANGULAR VIBRATIONS IN MARINE PROPELLING MACHINERY."

To the Editor of Engineering.

Sir,—I shall be glad if you would bring the following few notes on the valuable and instructive article by Mr. R. Gardner, on "Angular Vibrations," published in your Journal on September 9, page 363, to the notice of the author.

The comparison suggested by him has been worked out by me for many actual ships, and has been found to give very consistent results, clearly showing the valuable effect of substituting a heavier gear wheel; excepting—and this is the point in question—in the case of vessels with machinery aft, in which cases n is found to be greater than m, and any variation of the gear wheel appears to have practically no effect (or even a slight adverse effect) on the value of $R \times \Theta_2$.

Take the following example of a vessels of say 5,000 s.h.p., r.p.m. = 70. Shafting 18 in. diameter, length $l = 35$ ft. $\times$ 12 = 420 in. Propeller 22 ft. diameter, $I_1 = 130 \times 10^6$ lb.-in.^{2}. Now take gear wheel 130 in. diameter, $I_2 = 142 \times 10^6$.

Then $m = 4{\cdot}67$. $\gamma = 0{\cdot}36 \times 10^6$
$n = 6{\cdot}49$. $\Theta_2 = 0{\cdot}00122$.
$R \times \Theta_2 = 0{\cdot}0795$.

Now take a lighter and smaller gear wheel of 100 in. diameter:

$I_2 = 53 \times 10^6$.

Then $n = 8{\cdot}76$. $\Theta_2 = 0{\cdot}00121$.
$R \times \Theta_2 = 0{\cdot}0606$.

Taking a very heavy wheel, 140 in. diameter:

$I_2 = 246 \times 10^6$.

Now $n = 5{\cdot}81$. $\Theta_2 = 0{\cdot}0012$.
$R \times \Theta_2 = 0{\cdot}084$.

From these results it will be observed that even such large variations in the moments of inertia of the gear wheel leave Θ_2 constant, and $R \times \Theta_2$ almost constant, or in this case varying slightly in the opposite direction to what is expected.

Perhaps Mr. Gardner will, from his experiences with this theory, enlighten us as to how this anomaly may be avoided, as it makes this system of comparison useless in most cases where the machinery is placed aft, and it is well known that these latter are the most troublesome cases at present.

Yours faithfully,
"Node."

October 18, 1921.

[A copy of the above letter was forwarded to Mr. Gardner, who has sent us the following comments.—Ed.E.] "With the shafting and propeller dimensions quoted and with a node located at the gearing, there is synchronism at 70 r.p.m. between the disturbance and the natural vibrations of the shafting. This synchronism, as stated on page 364, was found actually to occur. Thus, the node being at the gearing instead of in its intermediate or "natural" position, we cannot bring this case under the system of comparison in question. If we could, then the value of $R \times \Theta_2 = 0{\cdot}0795$ in. would be quite satisfactory, and the question of improving it would not arise.

With a node at the gear wheel, the natural frequency of the shafting is

$$n = 3400 \times \frac{\pi^2}{\sqrt{I_1\,l}}$$

and improved conditions can be sought only in the direction of reducing the value of

$$\Theta_1 = \frac{\gamma}{I_1} \times \frac{9 \cdot 8}{n^2 - m^2}$$

It may well be asked, Why should a length of propeller shafting vibrate sometimes with a node at the gearing, sometimes with a node in the intermediate position? A vibrating system has, generally, several modes of vibration, corresponding to different numbers and positions of nodes, corresponding also to different frequencies of vibration. A periodic disturbance seems to excite that mode of vibration which has a frequency most proximate to its own. Take an ordinary cargo boat. With a node at the gear wheel, n is about 2 per second; with node intermediate, n is about 3 per second. At full speed, m is about 5 per second. We have the conditions assumed as a basis for our system of comparison. For the tanker, taking "Node's" figures, n is 4·7 per second when the gear wheel is the nodal point and is 6·49 when the node is intermediate. m is 4·67 per second at 70 r.p.m. Synchronous vibration will occur at 70 r.p.m.—R. Gardner."

Personal.—Messrs. Rudge Whitworth, Limited, Coventry, point out that of the 388 chassis exhibited at the recent Paris Salon, no less than 103 were fitted with Rudge Whitworth detachable wire wheels and 46 more had wheels manufactured under the company's patents.—Messrs. Wolseley Motors, Limited, of Adderley Park, Birmingham, have now opened their new motor car show-rooms at Wolseley House, 157 to 160, Piccadilly, London, W. 1.

THE MACHINERY OF THE FOUR-SCREW GEARED TURBINE S.S. "GIULIO CESARE."

CONSTRUCTED BY THE WALLSEND SLIPWAY AND ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

Fig. 9. SECTION ABOUT FRAME No 154, LOOKING AFT.

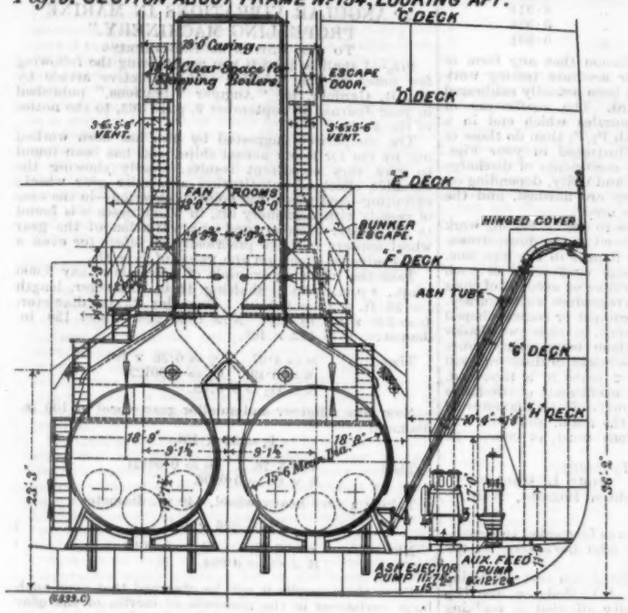


Fig. 10. SECTION LOOKING FORWARD SHOWING H.P. PINION

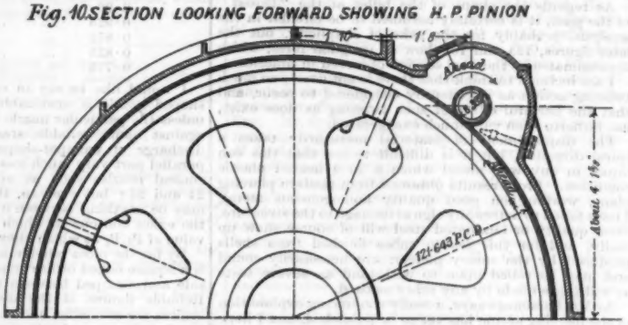


Fig. 11. H.P. PINIONS & BEARINGS

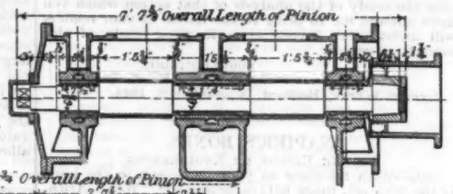


Fig. 12. L.P. PINIONS & BEARINGS

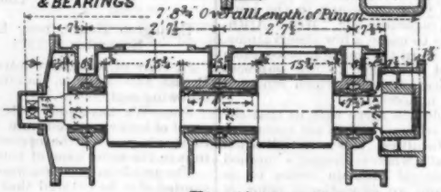


Fig. 13. SECTION LOOKING FORWARD SHOWING L.P. PINION

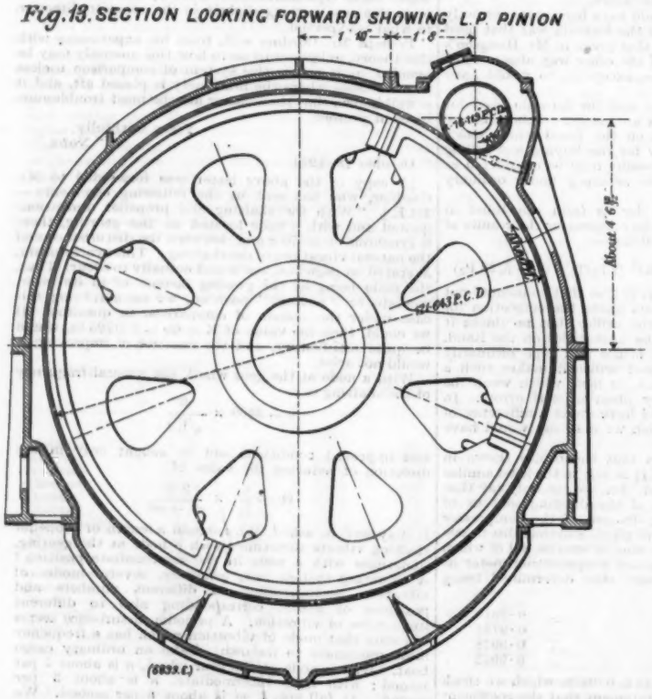
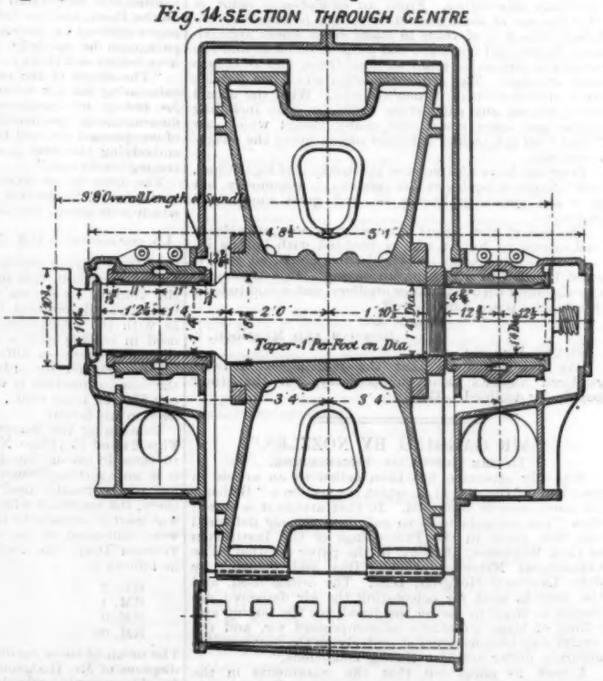


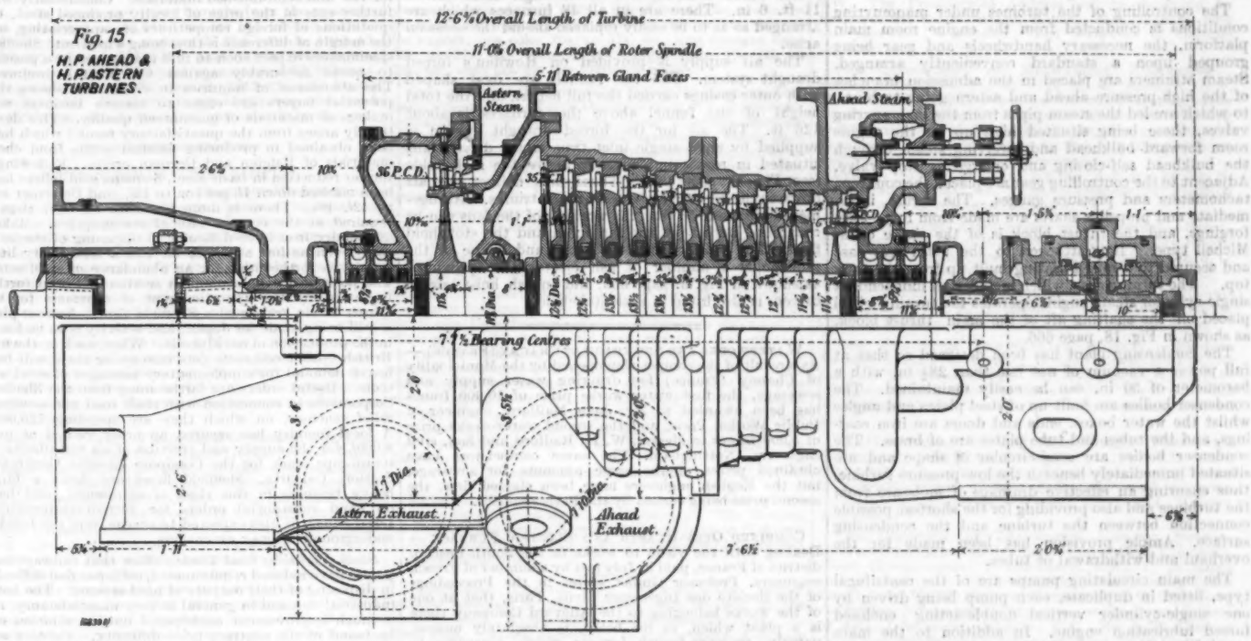
Fig. 14. SECTION THROUGH CENTRE

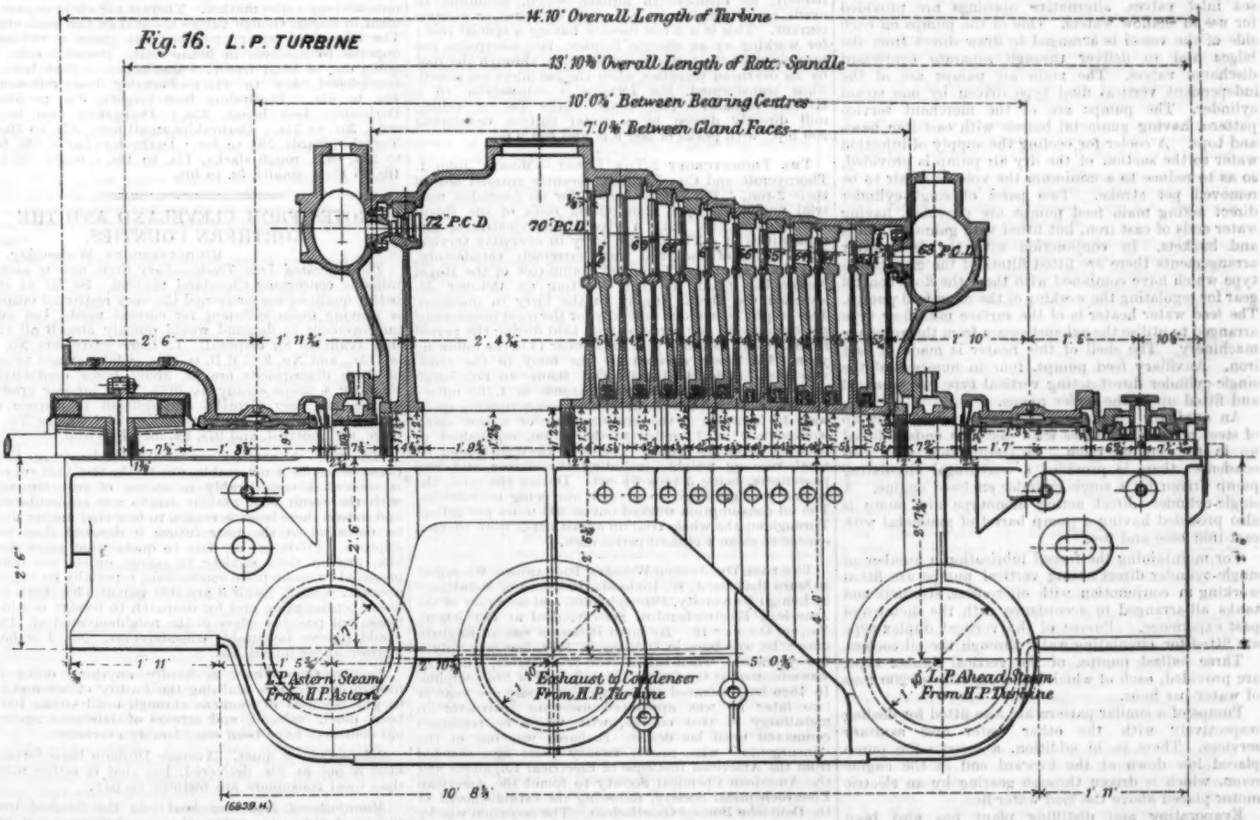


In our issue of March 18 last, page 323, we gave a general description of the passenger liner Giulio Cesare, constructed by Messrs. Swan, Hunter and Wigham Richardson, for the passenger service between Genoa and Buenos Ayres. We now describe her machinery in greater detail. The boiler room is shown in Figs. 1 and 2, on our two-page plate, the latter omitting the starboard bunkers, whilst Figs. 3 to 8 show the engine room. The vessel, which attained on her six-hour full power trial a speed of 19¼ knots, has four screws driven through single reduction gear by impulse steam turbines developing in the aggregate 21,000 shaft horse-power, and supplied with steam by six double-ended and four single-ended boilers, designed for a working pressure of 220 lb. per square inch and fitted with superheaters with which a superheat of 200 deg. F. can be maintained on the turbine manœuvring valves. The whole of the boilers and main machinery and part of the auxiliary machinery has been constructed and installed by the Wallsend Slipway and Engineering Company, Limited. There are two sets of ahead turbines, viz., a high-pressure and a low-pressure turbine on each side of the ship driving independent shafts. Fig. 17, page 664, is reproduced from a photograph and shows the forward ends of the two turbines, whilst Fig. 18 on the same page is reproduced from a photograph taken from the after end and shows the gear cases and also the working gear. A section through the high pressure turbine is represented in Fig. 15, page 663. From this it will be seen that the ahead section consists of 10 simple impulse wheels preceded by a velocity compounded stage having two rows of blades on the wheel. This arrangement allows of a large drop of pressure at the first stage so that high superheats and pressures are confined to the nozzle boxes on the front cover, thus minimising possible dangers from distortion. The nozzles supplying the first wheel are arranged in groups, each fitted with its own control valve. This arrangement reduces the consumption of steam when running at low powers. Comprised in the same casing is an astern turbine, which is a velocity compounded wheel having three rows of moving blades. It is, it will be seen, completely partitioned off from the ahead turbine, this arrangement being necessary because

TURBINES OF THE FOUR-SCREW GEARED TURBINE S.S. "GIULIO CESARE."

CONSTRUCTED BY THE WALLSEND SLIPWAY AND ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.





the exhaust steam from this high-pressure reverse turbine is discharged to the low-pressure reverse turbine, so that two connecting pipes are required between the two turbines. A section through the low-pressure turbine is represented in Fig. 16, above. The ahead section, in this case, consists of 11 simple impulse wheels, and the astern section of a three-stage velocity compounded wheel as shown.

In normal conditions the two turbines work in series, but provision is made for operating either independently should the necessity arise. The adjusting or thrust blocks are fitted at the forward ends of the turbines and are of the Michell type. The turbine shafts and wheels are steel forgings, and phosphor bronze is used for the blading. The casings are for the most part of cast iron, but steel castings are used for that part of the high-pressure turbine where high temperature may prevail. The diaphragms are of cast iron with nickel steel guide blades cast in. As is customary, forced lubrication is fitted to all the bearings.

The turbines drive their pinions through flexible claw couplings of forged steel. Sections through the gear casings are given in Figs. 10, 13 and 14, on the opposite page, and, as shown in Figs. 11 and 12, the pinions are supported by a central bearing. The body of the gear wheel is of cast iron, but the teeth are cut in forged steel rings which are shrunk upon the cast-iron centres. In the pinions nickel steel has been used. The gear casings are of cast iron and have been designed so as to be easily opened up for examination or overhaul.

As is well known, the satisfactory working of these high speed gears is dependant upon an ample and continuous supply of lubricant to the teeth, and to this end oil sprayers are provided as indicated underneath the pinions in Figs. 10 and 13.

The controlling of the turbines under manœuvring conditions is conducted from the engine room main platform, the necessary handwheels and gear being grouped upon a standard conveniently arranged. Steam strainers are placed in the admission branches of the high-pressure ahead and astern going turbines, to which are led the steam pipes from the manœuvring valves, these being situated high up on the engine room forward bulkhead and receiving steam through the bulkhead self-closing and emergency stop valve. Adjacent to the controlling gear are placed the counters, tachometers and pressure gauges. The thrust, intermediate and propeller shafts are made from ingot steel forgings, and the thrust block is of the single collar Michell type. It is attached to the main gear case and secured to a raised seating built up from the tank top. The turning gear, which includes an independent single-cylinder steam engine operates the turning wheel placed on the shafting aft of the main thrust block, as shown in Fig. 18, page 666.

The condensing plant has been designed so that at full power a vacuum of not less than 28½ in. with a barometer of 30 in. can be easily maintained. The condenser bodies are built up of steel plates and angles whilst the water boxes, ends and doors are iron castings, and the tubes and tube plates are of brass. The condenser bodies are semi-circular in shape and are situated immediately beneath the low-pressure turbine, thus ensuring an effective drainage of moisture from the turbines and also providing for the shortest possible connection between the turbine and the condensing surface. Ample provision has been made for the overhaul and withdrawal of tubes.

The main circulating pumps are of the centrifugal type, fitted in duplicate, each pump being driven by one single-cylinder vertical double-acting enclosed forced lubrication engine. In addition to the main sea inlet valves, alternative openings are provided for use in shallow waters. One of the pumps on each side of the vessel is arranged to draw direct from the bilges and to deliver through separate overboard discharge valves. The main air pumps are of the independent vertical dual type driven by one steam cylinder. The pumps are of the merchant service pattern, having gunmetal barrels with cast-iron bases and tops. A cooler for cooling the supply of injection water to the suction of the dry air pump is provided, so as to reduce to a minimum the volume of air to be removed per stroke. Two pairs of single-cylinder direct acting main feed pumps are provided, having water ends of cast iron, but fitted with gunmetal liners and buckets. In conjunction with the feed water arrangements there are fitted filters of the gravitation type which have combined with them the float control gear for regulating the working of the main feed pumps. The feed water heater is of the surface multiflow type arranged to utilise the exhaust steam from the auxiliary machinery. The shell of this heater is made of cast iron. Auxiliary feed pumps, four in number, of the single-cylinder direct-acting vertical type are supplied and fitted up in the boiler rooms.

An auxiliary condenser having the shell built up of steel plates and angles with cast-iron ends is fitted up in the engine room. In conjunction with this condenser there is provided a centrifugal circulating pump driven by a single-cylinder enclosed engine. A single-cylinder direct acting monotype air pump is also provided having a pump barrel of gunmetal with cast-iron base and top.

For maintaining the forced lubrication a number of single-cylinder direct acting vertical pumps are fitted working in conjunction with oil coolers, strainers and tanks all arranged in accordance with the dictates of past experience. Pumps of the vertical duplex type are fitted for circulating water through the oil coolers.

Three ballast pumps, of the vertical duplex type, are provided, each of which has a capacity of 200 tons of water per hour.

Pumps of a similar pattern are also fitted for dealing respectively with the other water and sanitary services. There is, in addition, a reserve fire pump placed low down at the forward end of the engine room, which is driven through gearing by an electric motor placed above the load water line.

Evaporating and distilling plant has also been supplied by the machinery contractors and comprises two vertical evaporators each capable of supplying 72 tons of water per day. They are heated with steam taken directly from the boiler. These evaporators are fitted with self-feeding and continuous brining arrangement. For supplying circulating water to the distillers two pumps of the vertical duplex type are fitted.

The boilers are of the ordinary multitubular type, as already mentioned. There are six double-ended and four single-ended boilers, the whole of which are arranged in four watertight compartments with the single-ended boilers placed aft. The boilers are all 15 ft. 6 in. in diameter, while the length of the double-ended boilers is 22 ft. and of the single-ended boilers 11 ft. 6 in. There are in all 48 furnaces which are arranged so as to be easily replaced should the occasion arise.

The air supply is provided on Howden's forced draught system. The two funnels are oval shaped with outer casings carried the full height, and the total height of the funnel above the furnaces is about 126 ft. The air for the forced draught system is supplied by eight single inlet type motor driven fans situated in rooms immediately above the stokeholds (see Fig. 9, page 662). These fans deliver the air down to the air heating boxes through trunks. Arrangements are made so that the working of the fans can be controlled both from the fan room and the stokehold floor. For dealing with the ashes and refuse of the stokeholds a number of ash ejectors are provided, as shown in Fig. 9, page 662, and an ash hoist, steam driven, is also fitted in each stokehold.

WATERWORKS AND SEWERAGE AT CHAUNY (FRANCE).—As a result of the competition opened by the Municipality of Chauny (France) for drinking water supply and sewerage, the first water works prize of 10,000 francs has been awarded to Mr. Jean Maillard, engineer of Public Works, Paris, and the second water-works prize of 5,000 francs to Messrs. W. H. Radford and Son, civil engineers, Nottingham. The same competitors have obtained prizes of the same amounts for sewerage, but the English engineers have been classed first, the second prize being earned by the Paris engineer.

COMBINED OPEN-HEARTH AND ELECTRIC FURNACE.—Dealing with the visits to works in the South-Eastern district of France, paid in July last by a number of French engineers, Professor Guillet states in the Proceedings of the Société des Ingénieurs Civils, Paris, that at one of the works belonging to the Allevard Company there is a plant which, to his belief, is absolutely unique, namely, an open-hearth furnace which, according to needs or circumstances can work with gas or electric current. This is a 5-ton furnace having a special roof; for working as an electric furnace, two electrodes are brought over the furnace and let down through the roof by an overhead traveller, when the gas inlets are closed. Thus transformed, the furnace is comparable to a Héroult furnace. The same works has a rolling mill directly driven by a water turbine developing 300 h.p., with peaks of 500 h.p. and 600 h.p.

THE THORNYCROFT 2-TON LORRY.—Messrs. John I. Thornycroft and Co., Limited, recently entered one of their 2-ton, "B.T." type lorries for an extended road trial under the open competition rules of the Royal Automobile Club, with a view to demonstrating the capabilities of a Thornycroft lorry in everyday service. The results of the trial were extremely satisfactory, and the Expert and Technical Committee of the Royal Automobile Club, at their meeting on October 20, awarded the Dewar trophy to the lorry in question. This trophy is awarded annually for the most meritorious performance in any certified trial held during the period from October 15 in one year to October 14 in the following year. The route covered by the lorry in the trials was from London to Land's End, thence to Edinburgh and back to London, a total distance of 1,260 miles; the trial occupied ten days. The average running speed was 15·9 m.p.h.; the consumption of motor spirit worked out at 13 miles to the gallon, equivalent to 69·3 ton-miles per gallon. The lorry was fully loaded, its total running weight, including the driver and two passengers, being 5 tons 6¼ cwt. During the trial, the engine was governed to prevent its being over-driven. The oil consumption worked out at 504 miles per gallon. Throughout the whole trial no adjustments were effected except to clean a choked petrol cock.

THE LATE DR. JOSEPH WILLIAM RICHARDS.—We regret to learn that Dr. J. W. Richards, Professor of Metallurgy at Lehigh University, Pennsylvania, and secretary of the American Electrochemical Society, died at Bethlehem, Pa., on October 12. By birth Richards was an Englishman; he was born in Oldbury in 1864, but was only a few years old, when taken over to America, where he was educated at the Central High School of Philadelphia. In 1886 he graduated at Lehigh University; a year or two later he was appointed assistant instructor in metallurgy at that college, with which he remained connected until his death. Richards was one of the "insurgents" who, nearly twenty years ago, seceded from the American Institute of Electrical Engineers and the American Chemical Society to found the American Electrochemical Society, following the establishment of the Deutsche Bunsen Gesellschaft. The secession was by no means regarded with favour by the two main institutions from which the new Electrochemical Society drew most of its members: but the new body soon justified its right of existence, and it has grown into a very large and influential Institution. Richards was its first president and was elected its secretary in 1907; that appointment he likewise retained till the end. He died of heart failure. He was a very active man, wrote a few books, and started, together with Dr. Roeber, in 1902, the journal *Electrochemical Industry*, first a monthly, now a weekly under the title *Chemical and Metallurgical Engineering*, and a leading journal in this field.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—A more normal condition of affairs is gradually beginning to establish itself in the market for raw and semi-finished materials. Concurrently with further cuts in the price of locally produced steel, the quotations of foreign competitors are appreciating, and the margin of difference is thus being wiped out. Sheffield steelmakers expect soon to find themselves in a position to quote favourably against Continental producers. The abundance of inquiries in circulation shows that potential buyers are eager to resume business with makers of materials of guaranteed quality. This desire largely arises from the unsatisfactory results which have been obtained in producing finished goods from cheap materials of Belgian and German origin. Following a similar reduction in basic steel, Siemens acid billets have been marked down 1*l.* per ton to 13*l.*, and Bessemer acid to 12*l.* 10*s.* There is more hematite on offer than is required at the current rate of consumption. Makers of foundry iron have difficulty in disposing of stocks at rates even as low as 5*l.* to 5*l.* 15*s.* a ton. Very little inquiry is forthcoming for an abundance of steel scrap. The position in the armament section has been further improved by the apportionment of contracts for the fourth battle cruiser to a Sheffield firm. Armour-plate is still being made for Japan, and activity is to be found in the production of naval shells. When work on the new British cruiser contracts gets into swing there will be a heavy demand for supplementary tonnages of steel and tools. Useful orders are forthcoming from the Sheffield Corporation in connection with their road and sewerage relief schemes, on which they are spending 125,000*l.* A local foundry has secured an order valued at over 8,000*l.* for the supply and erection of an installation of steam-pipe work for the Cossipore Electric Generating Station, Calcutta. Sheffield firms are doing a fairly heavy business in this class of equipment, and have on hand substantial orders for British corporations. Local benefit is also expected to accrue from the London underground railway extensions.

South Yorkshire Coal Trade.—Now that railway companies have reduced requirements, collieries find difficulty in disposing of their outputs of hard steams. The home industrial demand in general is very unsatisfactory, nor is much improvement anticipated until a solution can be found of the contract price difficulty. Cobbles and nuts are only a slow market. There is a shade of improvement in slacks, though values are still on the weak side. The advent of wintry weather has given a welcome impetus to business in house coal. Foundry coke is going out of hand freely. Quotations:—Best branch handpicked, 40*s.* to 41*s.*; Barnsley best Silkstone, 40*s.* to 41*s.*; Derbyshire best brights, 35*s.* to 36*s.*; Derbyshire best house, 35*s.*; Derbyshire best large nuts, 30*s.* to 32*s.*; Derbyshire small nuts, 27*s.* to 29*s.*; Yorkshire hards, 29*s.* to 30*s.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; rough slacks, 17*s.* to 18*s.*; nutty slacks, 16*s.* to 17*s.*; smalls, 5*s.* to 10*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Very little new is ascertainable concerning Cleveland pig-iron. So far as the better qualities are concerned the very restricted output is proving quite sufficient for current needs, but any improvement in demand would quickly absorb all the iron available for disposal. To home customers No. 1 is 115*s.*, and No. 3 G.M.B. is 110*s.*, whilst export prices of these descriptions are 5*s.* above home quotations. Foundry 4 keeps steady at 105*s.* The inferior grades of iron are very plentiful and difficult to dispose of at the recognised market quotations of 100*s.* for No. 4 forge, and mottled, and 97*s.* 6*d.* for white iron.

Hematite.—A marked downward tendency in East Coast hematite is noticeable, due to the fact that supply is somewhat considerably in excess of requirements, with the result that makers stocks are accumulating, and indeed there is some reason to fear that output may be curtailed in the near future if demand does not improve. Producers are free to quote what rates they like, and in their anxiety to secure orders are quite prepared to make price concessions, especially on export account. Nos. 1, 2 and 3 are still put at 120*s.* both for home consumption and for despatch to foreign destinations, but possibly offers in the neighbourhood of 115*s.* would receive favourable consideration. No. 1 is half a crown above mixed Nos.

Foreign Ore.—There is hardly anything doing in foreign ore, traders realising the futility of attempting to put business of moment through until stocks have been much reduced, and arrears of deliveries against old contracts have been considerably overtaken.

Coke.—Coke is quiet. Average Durham blast-furnace kind is put at 30*s.* delivered, but that is rather more than local consumers are inclined to pay.

Manufactured Iron and Steel.—In the finished iron and steel industries orders that are being secured are for small parcels. The only quotable change this week is a drop of 10*s.* in billets. The following are among the principal market rates:—Common iron bars, 14*l.*; steel boiler plates, 16*l.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; steel joists, 10*l.* 10*s.*; heavy steel rails, 10*l.* 10*s.*; fishplates, 15*l.* 10*s.*; black sheets, 15*l.* 10*s.* to 16*l.*; and corrugated galvanised sheets, 19*l.*

Imports of Iron and Steel.—Interesting returns issued by the Tees Conservancy Commissioners this week give the iron and steel imports to the port of Middlesbrough

from Holland, Belgium, France, Norway and Germany for the twelve months ending October 31 last as compared with the corresponding periods of 1912–13 and 1913–14. Pig-iron imported in the past twelve months reached 78,615 tons, as compared with 1,346 tons in 1912–13, and 1,427 tons in 1913–14; plates, bars, angles, rails, sheets and joists brought from the countries named amounted to 20,948 tons for the twelve months ended October last, as against 23,718 tons in 1912–13, and 19,462 tons in 1913–14; and billets, blooms and slabs imported during the past year reached 34,782 tons, as compared with 46,521 tons in 1912–13, and 33,655 tons in 1913–14. October imports of pig-iron amounted to 20,832 tons—the heaviest of any month in the past year.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of Trade.—The industrial position in Scotland is still in a very depressed state, only a few concerns are running full time. On the whole, however, the outlook is much brighter, and although little improvement is expected this year it is fully anticipated that the month of January will see trade on the mend. Inquiries all round are better and quite a number of these have lately resulted in deals taking place, but no forward movement will be noticeable until buyers' and sellers' ideas as to prices become more uniform. Fuel has fallen in price and oneost charges are less than they were, Therefore easier quotations are the order of the day. The world's markets are fairly bare and buying must take place soon, but financial conditions abroad are far from satisfactory yet.

Scottish Steel Trade.—The general depression which has prevailed throughout the country recently and which has been felt rather severely by the Scottish steel-makers, has shown little sign of lifting yet and the works are very badly off for orders. The limited amount of plant now in operation is scarcely kept fully employed, and it is frequently difficult to see even a couple of days ahead. Cost of production is coming down very slowly with the result that makers cannot afford to go in for drastic cutting of prices in order to induce buying. On the other hand consumers are not inclined to enter into commitments until they think prices have reached a reasonable level, and the current demand for all kinds of steel material is therefore very poor. Sheet makers are also feeling the scarcity of orders and the foreign inquiries are very limited. The prices ruling to-day are as follow:—Boiler plates, 16*l.* per ton; ship plates, 12*l.* 10*s.* per ton; sections, 12*l.* per ton; and sheets, 13*l.* 15*s.* per ton, all delivered Glasgow. In some cases English makers are 2*l.* per ton lower, but the difference is due to special circumstances.

Malleable Iron Trade.—There is still little doing in the malleable iron trade of the West of Scotland, and bookings are very few and are mostly for urgent business. It is expected that when makers find it possible to again reduce their prices some buying will result, but this largely depends upon the amount of the cut as all buyers are acting with great caution at the present time. The current price for "crown" bars is 14*l.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—No change of any kind falls to be chronicled in connection with the pig-iron trade of Scotland, and producers are experiencing a very poor demand. Continental pig-iron is still a good way cheaper than that turned out locally, but the latter has been coming down steadily of late and may very soon be the better bargain for consumers. The difficulty at present is that users in general are all very quiet and require very little, as their outlook is rather obscure, and few of them can see much new work on this side of the New Year. The export trade is also very quiet and shipments are small. Hematite iron is in very poor demand by steelmakers. The following may be taken as the current quotations:—Foundry iron No. 1, 6*l.* 15*s.* per ton, No. 3 6*l.* 12*s.* 6*d.* per ton, both in trucks at producers' works; and hematite, 7*l.* 2*s.* 6*d.* per ton delivered at the steel works. These home prices show a slight decline over the week, and whenever a decent export inquiry appears producers are prepared to give quite a keen quotation.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Speaking generally, there is little change in the position of the coal market. In view of the probability of a reduction in railway rates in the near future buyers continue to conduct their operations on hand-to-mouth lines. Despite this the volume of foreign trade is fairly good, and numerous inquiries are in circulation, but the figures at which consumers are willing to come on generally are below what exporters are prepared to accept. A Brazilian railway is asking for c.i.f. prices for the supply of 150,000 tons of coal, and Indian importers are asking quotations for 250,000 tons of large and small combined. The inland inquiry is, however, restricted and consequently, though many collieries are still on stop or working irregularly, the quantity of large coal available is in excess of requirements and prices are easier. Best Admiralty large is obtainable at 26*s.* 6*d.* to 27*s.*, seconds 26*s.*, Monmouthshires 25*s.* to 26*s.* and best dry large 27*s.* Smalls, however, are relatively scarce and strong. In many cases collieries refuse to sell small without large, and in all instances ask and obtain a premium of from 6*d.* to 1*s.* per ton for small alone. Large, best smalls are round 18*s.* 6*d.*, seconds 18*s.* and ordinaries 17*s.*, while dry smalls are from 12*s.* to 15*s.*, according to quality. With stoppages so frequent a fair proportion of the small coal produced is not available for sale, colliery companies requiring it for use under their own boilers. Bituminous sized coals are round 30*s.* with dry nuts firm at 35*s.* and anthracites scarce and strong at 72*s.* 6*d.* Foreign exports last week totalled 428,000 tons, which quantity has only been exceeded in two previous weeks this year and once during 1920. Supplies of coke are more plentiful, and foundry coke is obtainable at 45*s.* to 50*s.* for export, gas coke 35*s.* to 37*s.* 6*d.*, and furnace coke 25*s.* to 27*s.* 6*d.* Patent fuel ranges from 27*s.* 6*d.* to 29*s.* 6*d.*, with the inquiry none too brisk.

Iron and Steel Trades.—The Welsh tin-plate workers have accepted the offer of the employers of a 10 per cent. reduction on the 7½ per cent. bonus to which they are entitled under the sliding scale agreement, which fixes the bonus according to the ascertained selling prices of bars. Though inquiries have been more active of late something like 60 per cent. of the Welsh rolling mills are still idle. The foreign demand shows some improvement, while home consumers are also making inquiries. For prompt business, makers ask 22*s.* 6*d.* per basic box, but for delivery a couple of months ahead supplies are obtainable at 21*s.* to 21*s.* 6*d.*

Dock Repair Work.—An interesting engineering feat has just been accomplished at the Cardiff Docks, where the gates leading to the East Basin, erected fifty-eight years ago, have been removed and two new gates put in their place. To get the old gates out and the new ones in timber catheads, ballasted with water tanks, were erected on each side of the lock. The gates were lifted and lowered by means of two steam winches and wire ropes passing over the catheads, and multiple sheave blocks. The old gates weighed about 70 tons each and the new ones 75 tons. They will be operated by four new hydraulic engines of the "Brotherhood" type, two for each gate.

PHYSICAL SCIENCE AND ECONOMICS.—The first of two lectures by Professor Soddy, of Oxford, on "The Bearing of Physical Science on Economics" was given at Birkbeck College, yesterday. The date of the second lecture will be announced later.

INDUSTRIAL LEAGUE AND COUNCIL.—The annual general meeting of the members will be held at the Central Hall, Westminster, on Wednesday next, the 16th inst. On the same day, in the evening, a lecture on "The Great Essential in Industry," is to be delivered at Caxton Hall, Victoria-street, by Mr. F. S. Button.

INSTITUTION OF NAVAL ARCHITECTS.—The Institution announces that the date for the opening of the next annual meetings will fall on Wednesday, April 5, 1922. The council will be pleased to consider papers on subjects relating to naval architecture or marine engineering. Such offers (or suggestions for papers on matters of interest to the Institution) should, if possible, be sent in by the close of the present year.

THE INSTITUTION OF ELECTRICAL ENGINEERS' LIBRARY.—The Council of the Institution of Electrical Engineers announce that they have decided to keep the library of the Institution open in future on two evenings each week until 9.30 p.m., or alternatively, one evening a week and Saturday afternoons until 5 p.m. In order to ascertain which days are most favoured by members the library will be kept open every week-day and every Saturday afternoon until Christmas, commencing on Monday, November 14.

ROYAL INSTITUTION.—The ninety-sixth Christmas course of juvenile lectures, founded at the Royal Institution in 1826 by Michael Faraday, will be delivered this year by Professor J. A. Fleming, F.R.S., on "Electric Waves and Wireless Telephony." The lectures, which will be experimentally illustrated, will be given on the following days at 3 o'clock. Thursday, December 29, "Surface Waves on Liquids"; December 31, "Waves in Air"; January 3, "The Telephone"; January 5, "Electric Oscillations"; January 7, "Electric Waves"; and January 10, "Wireless Telephony."

INSTITUTE OF MARINE ENGINEERS.—The attention of the Council of this Institute having been called to the proposed formation of an Advisory Committee to act in connection with the Royal Naval Reserve, the subject was discussed at a recent meeting of the Institute. It was resolved to suggest that there should be three or more representative engineers, experienced in marine engineering, on the committee, in order that the subject may receive the detailed attention which its importance demands. The desirability of placing the Royal Naval Reserve on a high standard in respect to efficiency, and in regard to duty to the Empire, is manifest, and the council is very desirous that every effort should be made to uphold and maintain it. The resolve has been put before the Lords of the Admiralty.

ANNUAL DINNER OF RUSTON-HORNSBY CAR AGENTS.—At the invitation of Messrs. C. B. Wardman and Co., Limited, the sole concessionaires of the Ruston-Hornsby car, a large company of agents and other guests dined together at the Savoy Restaurant on Friday last. The chair was taken by Mr. C. B. Wardman, who was supported by Mr. S. T. Lee, and the firm of Messrs. Ruston-Hornsby, Limited, were represented by Messrs. F. H. Livens, Victor Bone, T. C. Ives, and others. It was stated during the course of the evening that no new models of the Ruston-Hornsby car were to be produced this season. The business done at the Olympia Show had been most satisfactory, and the makers had many more car contracts in hand than at the corresponding date last year.

NOTICES OF MEETINGS.

THE PHYSICAL SOCIETY OF LONDON.—Friday, November 11, at 5 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, London, S.W. The Presidential Address will be delivered by Professor Sir W. H. Bragg, K.B.E., M.A., F.R.S., who will take as his subject "The Structure of Organic Crystals."

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 11, at 7 p.m., at Storey's Gate, St. James' Park, S.W., the first informal meeting of the session; the subject for discussion will be the "Heating and Ventilation of Factories." At this meeting the election of three members to the sub-committee in charge of these meetings will be made.

Friday, November 18, at 6 p.m. A paper by Mr. E. H. Saimon, D.Sc., on "The Machinery of Floating Docks" will be read and discussed.

THE KEIGHLEY ASSOCIATION OF ENGINEERS.—Saturday, November 12, at 6.30 p.m., in the Assembly Rooms of the Cycling Club, Cavendish-street, Keighley, Mr. O. C. Dinnerman, of Leeds, will lecture on "Control Gear."

THE SURVEYORS' INSTITUTION.—Monday, November 14, when Mr. J. H. Sabin, President, will read his Opening Address. The chair will be taken at 8 p.m.

THE BRADFORD ENGINEERING SOCIETY.—Monday, November 14, at 7.30 p.m., Lecture in the Hall of the Bradford Technical College. Mr. Harry Moss, A.M.I.E.E. (Member of Council of the Society) on "Electricity and Photography in Modern Warfare," illustrated by lantern slides.

THE INSTITUTION OF CIVIL ENGINEERS: YORKSHIRE ASSOCIATION.—Monday, November 14, at 7.30 p.m., in the Y.M.C.A., Albion-place, Leeds, Lieutenant-Colonel C. Russell Brown, D.S.O., R.E., will read a paper, entitled "Co-operation between Civil and Military Engineers."

THE INSTITUTE OF TRANSPORT.—Monday, November 14, at 5.30 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. 1. A paper will be read on "The Possibilities of Improving Train Loads," by Mr. H. Kelway Bamber, M.V.O. (Member). On Friday, November 18, at 5 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C., Mr. J. P. Thomas (Member) will deliver a lecture entitled "The Operation and Development of Urban Electric Railway Services."

THE INSTITUTION OF ELECTRICAL ENGINEERS: NORTH MIDLAND CENTRE.—Tuesday, November 15, at 6.45 p.m., Opening Meeting in the Hotel Metropole, Leeds; Reception by the chairman (Mr. W. E. Burnand); Inaugural Address by the chairman; Smoking Concert.

THE SHEFFIELD ASSOCIATION OF METALLURGISTS AND METALLURGICAL CHEMISTS.—Tuesday, November 15. A paper on "Springs," by Mr. C. E. Squire, will be read.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 15, at 6 p.m. Paper to be read: "The Indian Railway Gauge Problem," by Mr. Frederick George Royal-Dawson, M.Inst.C.E.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, November 15, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, London, when reports on "Progress during the Vacation" and "Developments in Gas Lamps and Electric Lamps and Lighting Appliances" will be presented.

THE SOCIETY OF GLASS TECHNOLOGY.—Wednesday, November 16, at 2.30 p.m., in the Fuel Department, The University, Leeds. Demonstration of an improved Gas Reversing Valve for Regenerative Furnaces, by Mr. F. W. Knowles; general discussion on "The Melting of Glass."

THE ROYAL SOCIETY OF ARTS.—Wednesday, November 16, at 4.30 p.m., "Modern Buildings in Cambridge and their Architecture," by Mr. T. H. Lyon, M.A., Director of Design in the University School of Architecture, Cambridge. Mr. Basil Oliver, F.R.I.B.A., will preside.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 17, at 6 p.m., in the Lecture Theatre of the Institution, Savoy-place, Victoria Embankment, W.C. 2. "Telephone Line Work in the United States," by Mr. E. S. Byng, Member.

THE ROYAL AERONAUTICAL SOCIETY.—Thursday, November 17, at 5.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. A paper on "The Requirements and Difficulties of Air Transport" will be read by Colonel Frank Searle.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 18, at 7 p.m., at Caxton Hall, Annual General Meeting.

THE JUNIOR INSTITUTION OF ENGINEERS: MIDLAND SECTION.—Friday, November 18, commencing at 7 p.m., at the Birmingham Chamber of Commerce, New-street, Birmingham. Lecture by Professor K. Neville Moss, O.B.E., M.Sc., "Coal-Mining in Great Britain."

THE DIESEL ENGINE USERS' ASSOCIATION.—Friday, November 18, at the Institution of Electrical Engineers, a paper on "Some Recent Developments in Mechanical Injection Oil Engines Using Heavy Oils," by Mr. Oswald Wans, is to be discussed.

THE WEST BROMWICH ENGINEERING SOCIETY.—Friday, November 18, at 7.30 p.m., at the Technical School. A paper on "Steel Tube Making," will be read by Mr. Frederick H. Moseley (Member), of Messrs. Accles and Pollock, Limited, Oldbury. Major J. Lees, J.P., will preside. Lantern and special demonstration models.

THE MACHINERY OF THE FOUR-SCREW GEARED TURBINE S.S. "GIULIO CESARE."

CONSTRUCTED BY THE WALLSEND SLIPWAY AND ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

(*For Description, see Page* 662.)

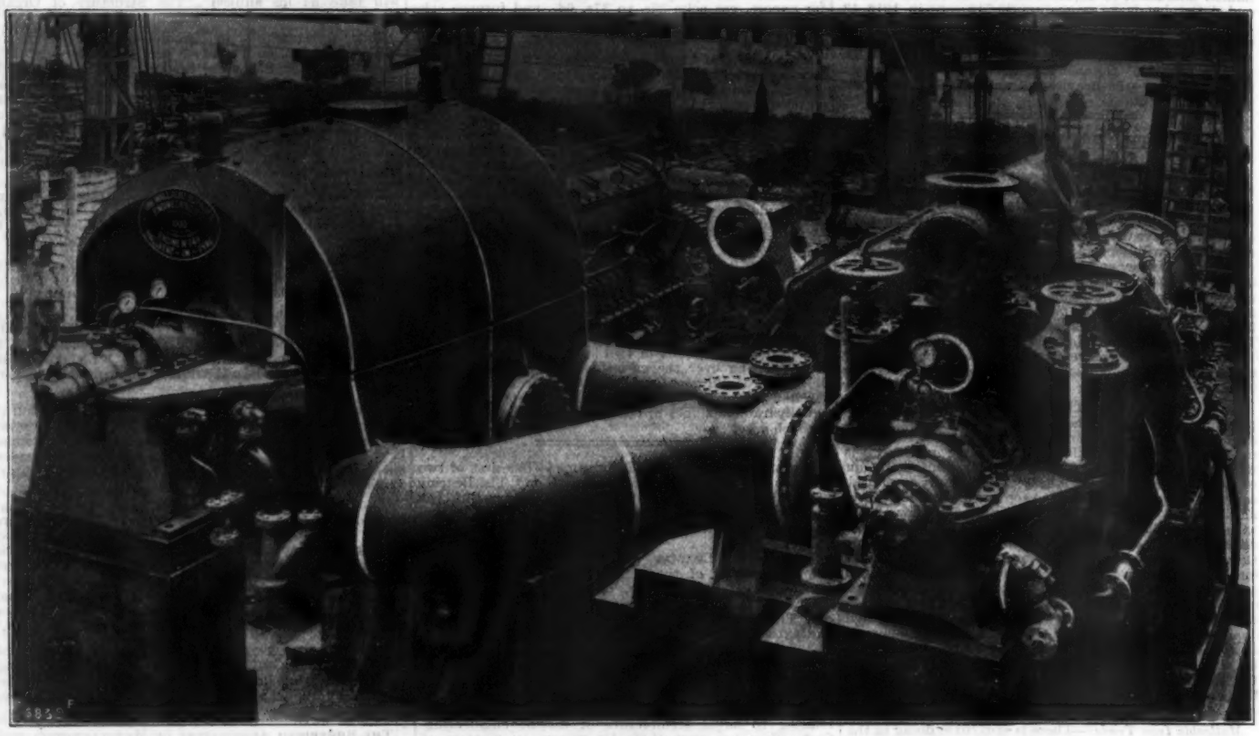


Fig. 17. View of Starboard Set of Turbines from Forward End.

Fig. 18. View of Starboard Set of Turbines from Aft End.

THE MACHINERY OF THE FOUR-SCREW GEARED TURBINE S.S. "GIULIO CESARE."

CONSTRUCTED BY THE WALLSEND SLIPWAY AND ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

(*For Description, see Page* 662.)

Fig. 1.

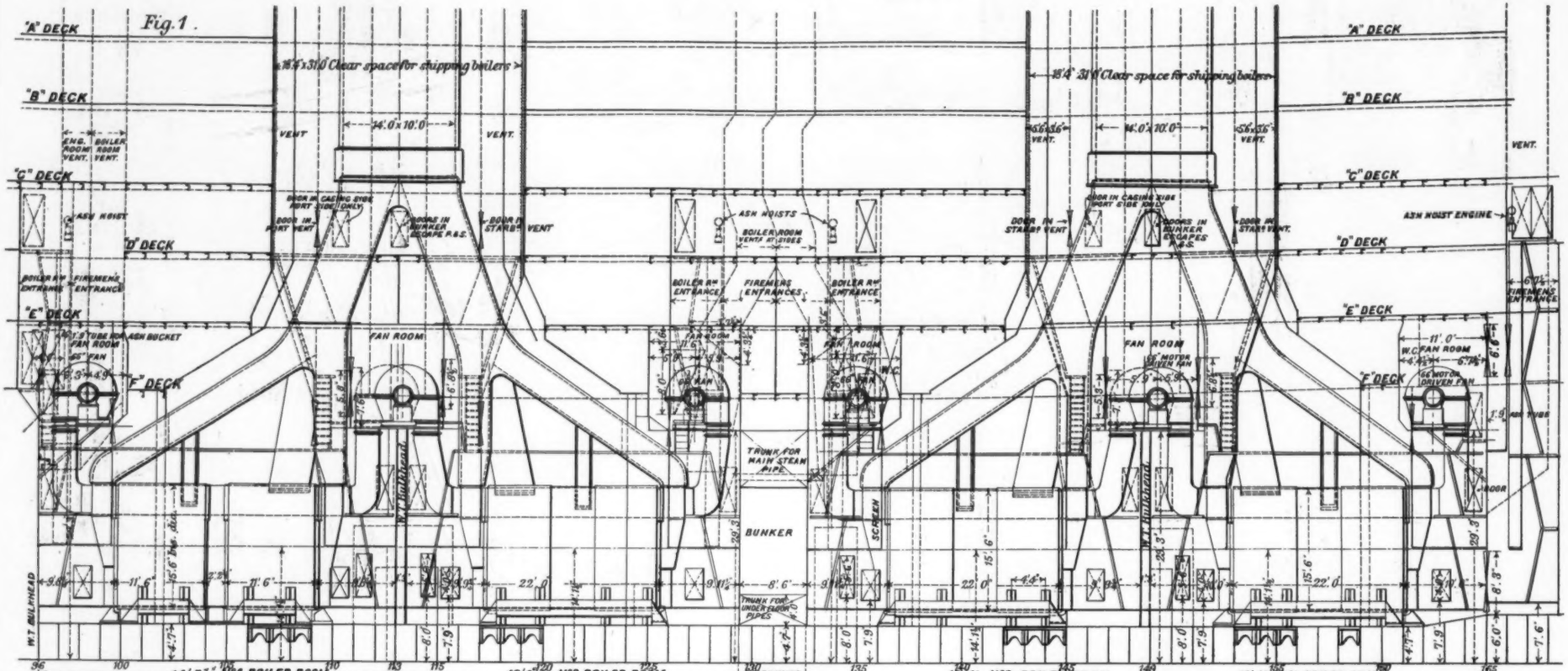
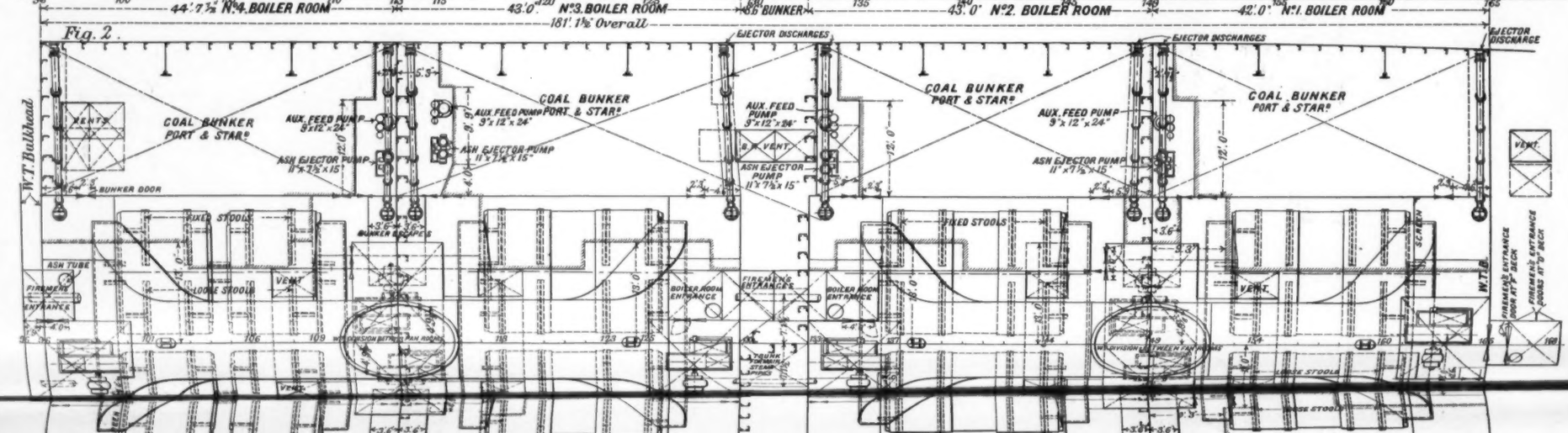


Fig. 2.



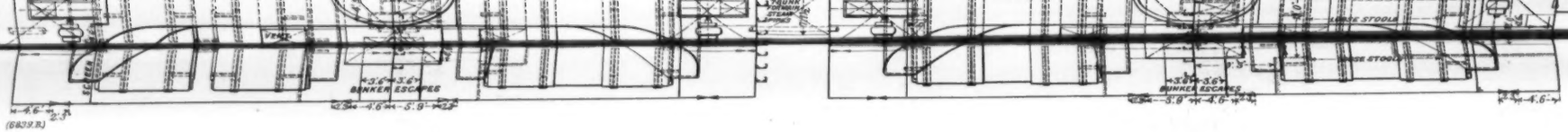


Fig. 3. ELEVATION OF WING SHAFTS.

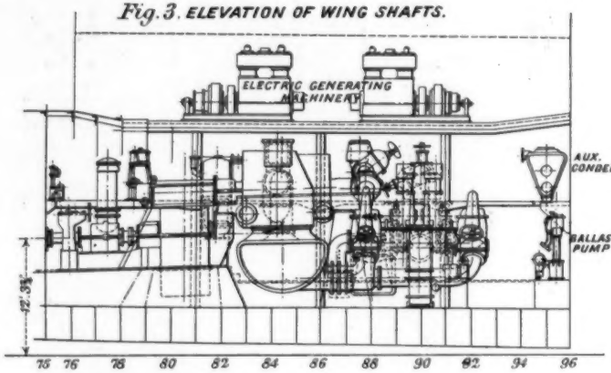


Fig. 4. SECTION LOOKING AFT ON 75 BULKH.

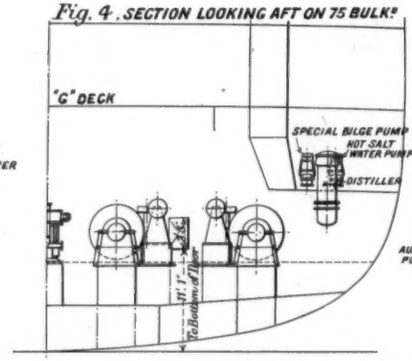


Fig. 5. SECTION AT 96 LOOKING FORWARD.

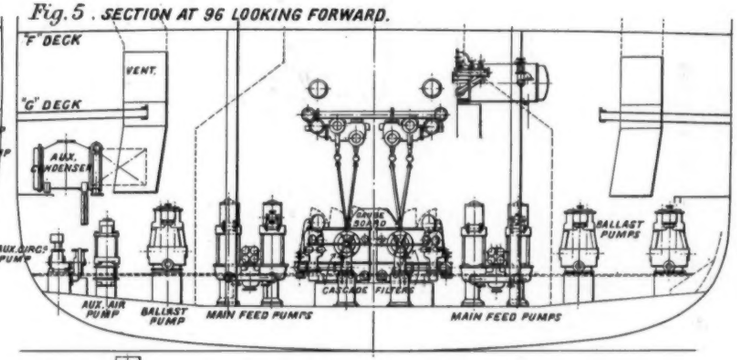


Fig. 6.

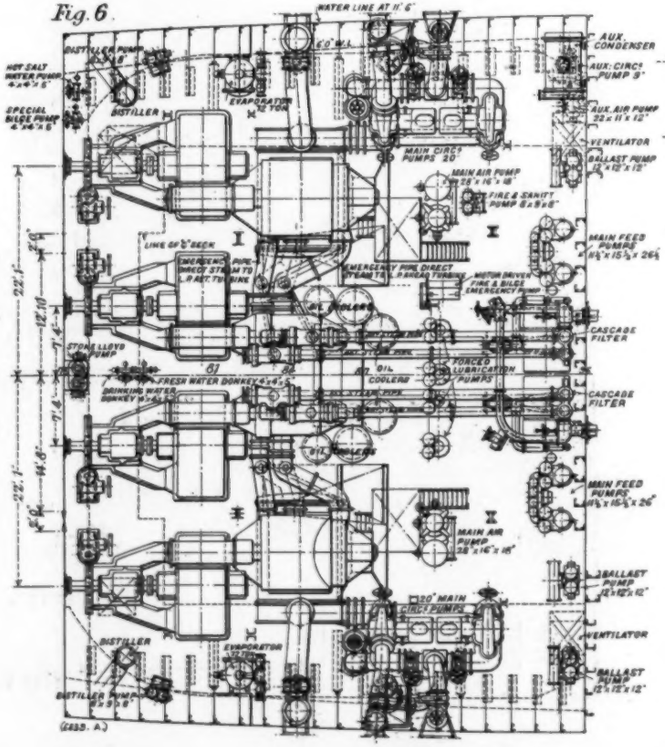

WATER LINE AT 11'-6"
AUX. CONDENSER
AUX. CIRC.S PUMP 9"
AUX. AIR PUMP 32 x 11 x 12"
BALLAST PUMP 12" x 12" x 12"
VENTILATOR
MAIN CIRC.S PUMPS 20"
MAIN AIR PUMP 28" x 16" x 18"
FIRE & SANITY PUMP 8" x 8" x 6"
MAIN FEED PUMPS 16½" x 15½" x 26"
CASCADE FILTER
CASCADE FILTER
MAIN FEED PUMPS 16½" x 15½" x 26"
MAIN AIR PUMP 28" x 16" x 18"
3 BALLAST PUMP 12" x 12" x 12"
20" MAIN CIRC.S PUMPS
VENTILATOR
BALLAST PUMP 12" x 12" x 12"
DISTILLER
EVAPORATOR
DISTILLER PUMP 5" x 5" x 6"
HOT SALT WATER PUMP 4 x 4" x 6"
SPECIAL BILGE PUMP 6 3/4" x 6"
DISTILLER
EVAPORATOR 12 TONS
STONE LLOYD PUMP
FRESH WATER DONKEY 4" x 4" x 6"
DRINKING WATER DONKEY 3" x 4" x 6"
EMERGENCY FUEL DIRECT
MOTOR DRIVEN FIRE & BILGE EMERGENCY PUMP
FORCED LUBRICATION PUMPS
AIR COOLERS
AIR COOLERS
LINE OF 2ND DECK
22'-1"
12'-10"
7'-4"
7'-4"
4'-8"
5'-9"
3'-0"
(2833. A.)

Fig. 7

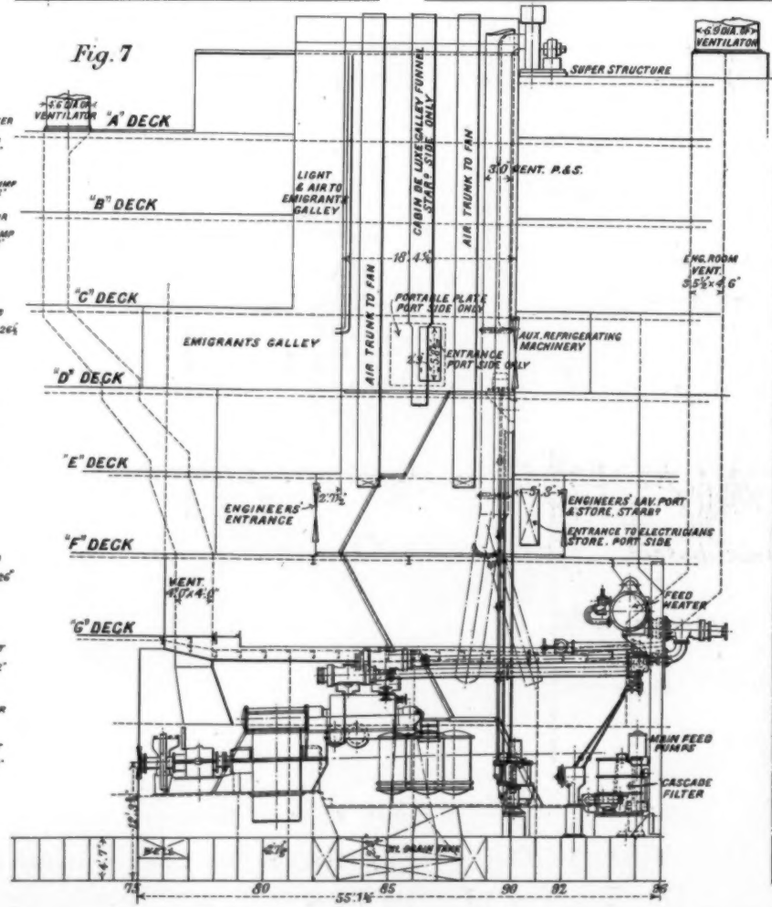
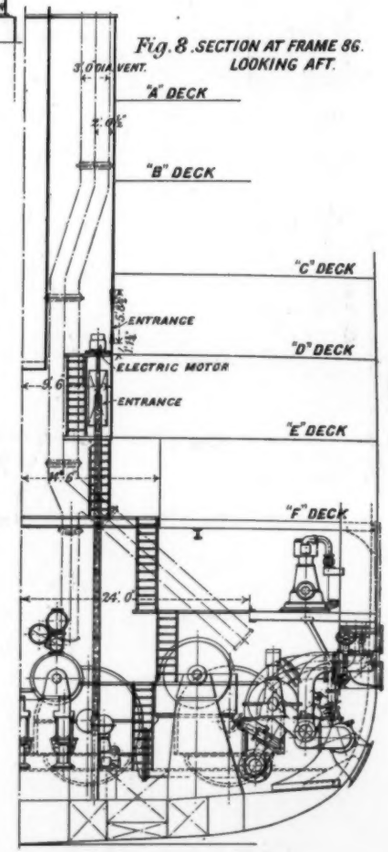


Fig. 8. SECTION AT FRAME 86. LOOKING AFT.



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The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

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Thin paper copies	£3 3 0
Thick paper copies	£3 7 6

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TELEPHONE NUMBERS—3663 and 8598 GERRARD

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NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 665.

ENGINEERING.

FRIDAY, NOVEMBER 11, 1921.

THE EDUCATION OF THE SKILLED WORKER.

QUITE recently discussing shop conditions with a member of the staff of an engineering firm, the name of which is a source of pride to every British engineer, we found that so many premium pupils were taken on by the firm that there was room for very few ordinary apprentices in the shops. The pupils paid a substantial fee for their training, but there was no reason to suppose that the policy of the firm was dictated by monetary considerations. The pupils were well looked after, they were passed through all departments and had special lectures and tuition arranged for them; while a hostel was provided for residence. The pupils after the completion of their training were by no means all retained in the firm, and the care which the firm devoted to their practical education represented valuable work for the good of the engineering profession generally.

The proceedings of this firm to which we have referred have, however, another aspect. The conditions obtaining in their shops make it impossible for other than a very few of the sons of working men to enter the firm and learn a trade. As the works are situated in a country town where there are few occupations available, this introduces a serious domestic difficulty for many of their own employees. The matter has a wider bearing, moreover. In the past it has been almost a prescriptive right that the sons of foreman and long-standing skilled employees should be received into their father's firm and taught a trade. This is a very valuable and wholesome custom, and little good is likely to come from its abandonment. At a time when the country is suffering from slack work, and a lack of interest in the fortunes of the firm and the industry with which only too many workers are connected, any breaking of the links between a firm and their employees is definitely an evil.

The apprenticeship which a skilled worker spends in learning his trade is a very important part of his general education. A working-class boy may now obtain a fairly comprehensive book education with no great difficulty, and he is compelled to obtain the modicum of one, but this education, while it may help him to become a more useful citizen and even a more useful skilled mechanic, will not in itself make him a skilled mechanic, and it is his quality of being, or not being, a skilled mechanic that will dictate his earning power and to a considerable extent his position in life. The fitters and turners of the engineering trades are made in our engineering shops and in spite of the manufacturing developments, which have transferred many skilled jobs to unskilled, or semi-skilled labour, such fitters and turners will be wanted equally in the future as in the past. Although from the schoolmaster's point of view the training which boys receive in our engineering workshops is no official part of any educational curriculum, it is in fact a very important item in the total educational procedure of the country, and it is greatly to be hoped that no serious hindrance to this form of education, such as that implied in the case we have quoted, will be generally introduced.

We do not know what proportion of those engaged in the engineering trades are occupied with manual work—the president of the Institution of Electrical Engineers suggests 80 per cent. The actual figure is, however, of no importance for our present purpose. Certain it is that by far the majority are so employed. This being so, and the country being hard up and with no money for luxuries, it is a very fair subject for inquiry if too much of our expenditure on education is not spent for the purpose of training youth for other than manual work. This is a very old subject of contention, but present economic conditions give it a fresh interest, and the attention devoted to it formed not the least valuable part of the presidential address which Mr. J. S. Highfield delivered to the Institution of Electrical Engineers on the 3rd inst. The line Mr. Highfield took concerned itself mainly with the training in schools, and he pointed out that many educational authorities are moving in the direction of a better realisation of the value of manual training than they have shown in the past.

The teaching of carpentry, gardening, &c., in schools, is a valuable move in the right direction, and it would be unfortunate if concurrently with the introduction of a better realisation of the relative values of "book education" and handicraft training in schools, those who are responsible for actual trade instruction, which will make, or mar, our future skilled men, take a move in the opposite direction. The firm to which we have referred, the practice of which is in no way unique, are in effect, if not in intention, acting in the same way as the schoolmaster, and are failing to realise the relative values of handicraft and "book learning" to the rising generation from which our skilled mechanics of the next generation must be drawn. It is useless for Mr. Highfield, or anyone else, to blame scholastic authorities for laying too much stress on what is after all their own calling, if engineers who are responsible for the only effective manual training which can be given, proceed themselves in such a way that they in effect also lay too much stress on the same subject.

After dealing with this educational matter Mr. Highfield, in the address to which we have referred, turned to economic questions and laid much stress on the necessity for adequate profits if industry is to succeed and increase. This question of a proper return on capital, so that not only may it be attracted, but also so that fresh capital shall continually be available for extension and the development of business, is a subject on which we have written not infrequently of late, and we need not now retrace the arguments. There is, however, an important connection between this subject and the education of the rising generation which Mr. Highfield did not stop to trace out. We have already referred to it incidentally. What is essentially the matter with this country at the present time is that we are spending more than we are earning. We are living on capital, and the capital is coming to an end. If we continue as we are, wages will decrease and the new standard of living will fall as surely as the sun will rise to-morrow.

This question is by no means one concerning the workers only, but they have a very important part in it. It has been very generally realised that one way in which things might be bettered would be by inducing the workers to take a keener interest in the facts of the industry by which they live. This idea has resulted in the introduction of various profit-sharing and co-operative schemes. There is much that is good in efforts of this kind, but without committing himself to any such heroic measures it is possible for the average employer to increase the interest of workpeople in the fortunes of the firm by which they are employed. The matter is largely one of personal treatment and relationship, which may be difficult features to introduce in a large organisation, but the particular aspect of such features with which we are now concerned presents no special difficulty. If every effort were made to take the sons of satisfactory skilled workers into the business in which their fathers are employed and to teach them a trade, much would be done to ensure loyalty and good service. A procedure of this kind is by no means unknown, but that it is not universal is shown by the case we have quoted.

In matters of this kind one must naturally retain a sense of proportion, and it is not necessary to suggest that premium apprenticeship should be abolished in order that the maximum number of workmen's sons may serve their time. All that is necessary is that the workpeople should obtain a fair proportion of the vacancies. The average workman is a reasonable being, and is quite prepared to recognise that members of another class than his own should be trained as engineers. A further aspect of this question may be referred to in concluding. That is the question of the future supply

of skilled workers. British engineering has owed much to its tradesmen, and if it is to continue to hold the place it has held, an adequate supply of such workers must be assured. The capstan lathe and the automatic machines are very important items in engineering manufacture, but without skilled backing they will not carry on the engineering tradition of this country, and enable it to make the advances which must be made by the country which is to hold first place.

MARITIME RISKS.

For an island community, such as ours, which is dependent for its existence upon sea transport, the question of maritime risks is always one of particular interest and importance. In normal times, the risk to life is very small, and even during the war period, when the dangers of the sea were enormously enhanced by enemy action, there was no dearth of crews to man our merchant ships or of passengers to occupy them. The sea, however, still takes its toll of life and property, and although the toll is now much lighter than was formerly the case, no practicable means by which the figure can be still further reduced should be neglected.

With this object in view, Sir Westcott S. Abell, in a valuable paper read before the North-East Coast Institution of Engineers and Shipbuilders on Friday last, analysed the statistical data for the British mercantile marine in pre-war days in order to indicate for what risks protection must still be provided, or, as he put it, to establish a criterion of risk. The author dealt with the period 1890–1913, for which the figures would be practically unaffected by the legislation following the Titanic disaster in 1912. In any case, the later figures covering the subsequent war period would obviously be of little service in considering normal conditions.

During the period referred to, the number of vessels registered in the United Kingdom and engaged in foreign trade increased from 3,600 to 4,100, and the average annual number of vessels in service was 3,788. On the average, casualties occurred to 1,751 of these vessels annually, *i.e.*, to over 46 per cent. Most of these casualties, however, were of a minor character, and only 572, or about 15 per cent., can be regarded as serious, including some total losses. The average number of accidents in which loss of life occurred amounted only to 46 per annum for the 23-year period under consideration, this figure being about 1·2 per cent. of the number of vessels employed.

The above-mentioned figures are, of course, of interest, in that they give some idea of the risks involved, but with respect to the future, it is more important to see to what extent these risks are diminishing with time. For this purpose Sir Westcott Abell compared the average figures for periods of nine consecutive years, and he thus arrived at the conclusion that the proportion of total casualties has declined from 55 per cent. at the commencement of the period under consideration to 39 per cent. at the end of that period, while the corresponding reduction in the number of serious casualties has been from 21 per cent. to 11 per cent. The reduction in the number of casualties involving loss of life has been less marked, having only declined from 1·5 per cent. to 1·2 per cent. during the period.

The next step towards the reduction of maritime risks is obviously to examine the causes to which such accidents as have occurred can be attributed, but in this the author is somewhat hampered by the fact that the only available statistics refer to vessels included in both the foreign and coasting trades. The risks in the latter are greater than in the former, so that the author's application of the results of his analysis to the deep-sea services is probably somewhat unfair to the latter; this point, however, he was careful to explain. Assuming then that the causes of casualties in the foreign trade are relatively proportionate to those in the whole of the steam merchant fleet of the United Kingdom, it would appear that those due to weather conditions amounted to about 16¼ per cent. at the commencement of the 23-year period, declined to some 13 per cent. in 1903–4 and rose to nearly 15 per cent. in 1913, the percentages being calculated on the number of vessels engaged in foreign trade. Casualties attributable to the human element amounted to 16¼ per cent. and 9¼ per cent. at the beginning and end of the period, respectively, while those due to defects in ships or machinery fell off from nearly 11 per cent. to under 7 per cent. The risk from fire, on the other hand, has actually increased, having risen from 1 per cent. to nearly 2½ per cent. in the period under review, while casualties from miscellaneous causes have declined from 11 per cent. to about 5½ per cent.

The same data expressed as percentages of the total number of casualties, instead of percentages of the total number of vessels employed, give the following results for the beginning and end of the 23-year period, respectively: Casualties due to weather increased from 30 per cent. to 38 per cent., casualties due to errors of *personnel* decreased from 30 per cent. to 25 per cent.; casualties due to *matériel* decreased from 19 per cent. to 17 per cent.; casualties due to fire increased from 1½ per cent. to 6 per cent.; casualties due to miscellaneous causes decreased from 20 per cent. to 14 per cent. It would therefore appear that, roughly speaking, about one-third of the accidents which occur at sea may be regarded as within human control.

In considering the question of loss of life, Sir Westcott Abell divided the subject into two logical headings, dealing respectively with the occupational risk of the crew and the risk to the passengers carried. The average death rate from all causes (including marine accident and disease) for the European crews of steam vessels registered in the United Kingdom and engaged in foreign trade, declined from 7·2 per 1,000 in 1890 to 4·3 per 1,000 in 1906–7, but increased again to about 4·5 per 1,000 at the end of the period under consideration, owing to the occurrence of the Titanic disaster; the corresponding figures for deaths from disease alone were 2·7 per 1,000 at the commencement of the period and 2 per 1,000 at the end. If very abnormal accidents are neglected, it thus appears that the occupational risk for European seamen employed on British vessels in the foreign trade is about 2 per 1,000, and it may be added that the latter figure does not greatly exceed that for underground workers in mines, which was about 1·7 per 1,000 in 1913.

The average death rate per passenger from accident and disease fell from 2·44 per thousand in 1890 to 1·4 per thousand in 1913, of which totals deaths from disease alone accounted for about 1·2 per thousand at the beginning of the period and declined to rather less than 1·1 per thousand at the end. The author showed that the deaths of passengers carried have declined from 700 per million in 1890 to about 150 per million in 1913, and it should be noted that the figure for the end of the period would be increased by the loss of the Titanic. It may here be mentioned that at least two abnormal casualties were included in the period under consideration, viz., the torpedoing of the Kow Shing in 1894, while carrying Chinese troops, which resulted in the loss of 1,150 passengers and 47 of the crew, and the Titanic disaster in 1912 whereby 825 passengers and 673 of the crew were lost. These two casualties alone account for over 40 per cent. of the total number of passengers lost in the 23-year period under consideration. For the whole period, the number of deaths of passengers at sea from disease is nearly four times as great as that due to marine accidents, while, at the end of the period, the proportion is about 8 to 1 and, if the two casualties above referred to be omitted, the proportion becomes practically 15 to 1. The risk of passengers dying at sea from natural causes is therefore very much greater than the risk of death from marine accidents; in fact the author shows that the latter are responsible only for the death of one passenger in every 10,000 carried.

For purposes of comparison Sir Westcott Abell quoted some statistics of traffic accidents in the United States for the period 1906 to 1918, and covering the registration area of that country which includes about 80 per cent. of the population. From these it appears that the total number of deaths from accidents connected with land travel averaged about 233 per annum per million of population. We would, however, point out that the average duration of a sea voyage is probably very considerably shorter than the average total time for which each member of the population is exposed to the risks of land travel during the course of a year. We have no idea what either of these figures is and the last mentioned would be difficult, if not impossible to obtain, but it seems to us to be necessary to call attention to the point to prevent the inference from being drawn that land travel is more than twice as dangerous as sea travel; we do not, of course, suggest that the author made any such contention. To us it appears that the relative safety of sea travel is best demonstrated by the small proportion of deaths from marine accidents to those which occur at sea from natural causes.

In conclusion, Sir Westcott Abell made some interesting deductions showing to what extent the loss of passenger life at sea may be reduced by improvements in naval architecture and marine engineering. Assuming that 1,000,000 passengers are carried annually and that the annual death roll is about 200 it would appear that, as only about one-third of the total number of casualties can be regarded as preventable, about 70 lives per annum would be saved by absolute perfection in the ship, if no consideration be given to the location of the casualty. To allow for this, the author showed that about 16 per cent. of the accidents which occur can be ascribed to deep-sea risks, 30 per cent. to off-shore risks (stranding) and 54 per cent. to miscellaneous causes. Technical regulations relating to the ship and her machinery, he pointed out, cannot provide against strandings, and only about half of the miscellaneous risks he regarded as being preventable by such means. This leaves only 43 per cent. of 70, *i.e.*, about 30, as the number of lives that might possibly be saved in each million passengers carried. Finally, we would point out that these deductions were made from figures applicable at the end of the 23-year period, just after the loss of the Titanic. To-day sea travel is, presumably, even safer owing to the legislation introduced in consequence of that event.

LABORATORY FUEL TESTS AND GAS-PRODUCER RESULTS.

When we wish to convert a fuel into producer gas we are mainly interested in four questions: What percentage of the heat in the fuel will be retained in the gas, what will be the heating value of the gas, what by-products can we recover, and what type of plant do we require? To answer those questions we have first to determine many things. Moisture, fuel grading and ash content we deduce from ultimate analyses; radiation and gas leakage losses and soot formation will depend upon the type of producer. To ascertain the products obtainable, the nature of the volatile matter, the losses in by-products and the heat values of the gases we have to perform distillation tests. Such tests will have to be conducted and subsequently examined with judicious care, and we are not sure after all whether the various tests will really enable us to predict what products we may hope to obtain in the producer and what the commercial balance will look like.

When the points referred to were discussed at the Society of Chemical Industry last Monday in connection with a paper by Mr. N. E. Rambush, engineer to the Power Gas Corporation of Stockton-on-Tees, on a "Comparison between Laboratory Fuel Tests and Practical Working Results of the Producer-Gas Process," the speakers agreed that tests such as described should enable us to form a fair estimate, and we are inclined to accept that, with qualifications. The difficulty about many tests is their interpretation; different methods and different apparatus might give different results, and standardisation of a method may mislead us sadly. But Mr. Rambush does not advocate standardising; he is going to continue his researches well aware of obscure problems left to be solved, his tables showed that he has been doing a very large amount of laborious work, and others are investigating the same field.

Mr. Rambush charges his horizontal distillation retorts of iron with 2 kg. of the fuel crushed to pieces of ¼ in. to ½ in., heats up slowly to 350 deg. or 400 deg. C., when British bituminous coal

generally begins to give off tar and gas freely, and then raises the heat to 800 deg., maintaining fairly steady conditions for 4 hours or 6 hours. The distillation products pass in series through a reflux air condenser, a down-flow water condenser and various absorbents, sulphuric acid, heavy petroleum, pure cresylic acid, and charcoal or cotton wool, finally into a gas meter and sample testing bottles which may also be joined to intermediate parts. The whole apparatus is designed not to be too elaborate for workshop practice. The remaining coke is immediately weighed and analysed, the condensates are classified as tars and volatile oils, liquor, ammonia, and the gases are analysed and tested in various ways for the purpose of obtaining weight balance sheets and thermal balance sheets. The many fuels of which Mr. Rambush gave such particulars comprised various coals, including samples from South Africa, lignite, peat and straw, and the tables record very numerous determinations. In several cases, large scale gasification values were available for comparison.

When the heat values of the original fuel and of the products are compared, there is always a loss of heat in the distillation figures, which has to be traced in detail, and the proportions of the products obtained in the laboratory and in the producer differ. Slow distillation generally gives more volatile tars than rapid distillation; Mr. Rambush recommended a distillation period of 4 hours to 6 hours (as mentioned) as likely best to correspond to the practical conditions. In continuous producer runs of 288 hours he obtained only about 10 per cent. of low-boiling products (up to 170 deg.), while in his laboratory tests up to 40 per cent. went into these more volatile products. Dr. Colman subsequently drew attention to this important feature and suggested performing the distillation in an atmosphere of producer gas; Dr. Lessing added that this gas should be drawn from the coke, not from the coal. The atmosphere is no doubt an important factor; but Dr. Colman's proposal would be difficult to carry out. Mr. Rambush obtained 7·24 per cent. of tar (reckoned on the ccal) in one of his tests, and 5·2 per cent. in the producer, and ascribed the smaller practical yield (about one-fifth less) to decomposition of some tar in the producer, and also to inefficient condensation of the lighter oils. In any case the tar yield varies a good deal with the fuel as one would expect; but the tar yield is not a function of the content of volatile matter, as is often asserted. That was one of the main points brought out by Mr. Rambush. Another point was that the coal should be dried before the distillation test, especially if very moist. The moisture would, of course, be allowed for, but the presence or absence of steam makes a great difference in the retort and producer, particularly as to the ammonia yield to which we shall presently refer.

We have, however, yet to learn a good deal about the "latent heat of distillation" in general. Exothermic reactions may take place in some fuels like peat and straw, which contain bound or absorbed oxygen. In one case Mr. Rambush calculated a distillation loss of heat of 16 per cent., and estimated the total gasification loss (due to moisture, soot, tar ashes, radiation and leakage) at 38 per cent. The thermal efficiency of the gas producer should thus have been about 60 per cent. or, including the thermal distillation loss observed in the laboratory (i.e., adding 16 to 38), about 46 per cent. A week's run in the producer gave an actual gasification efficiency of 57 per cent., which is in fair agreement with the 60 per cent. It would thus appear that the distillation-loss allowed for is utilised in the producer itself, and does not represent any actual gasification loss. Yet there are data wanting before we can determine the actual heating value of the producer gas from the figures of the distillation test. The heating value of producer gas generally runs from 110 B.Th.U. up to 180 B.Th.U. per cubic foot at normal temperature and pressure; but to determine the characteristics of the gas from the quantity of coke produced and the volume and composition of the distillation products is a very complicated problem. The coke remaining in the retort after the distillation will—apart from cases of exothermal heat evolution—have to give the heat which is required to make up for the thermal losses in the gas producer, and there must hence be a relation between the coke gasification efficiency and the gas-heating value.

As regards by-products, Mr. Rambush would at present regard an 80 per cent. tar recovery as a good practical yield, though he is now exceeding that figure—important since tar and tar oils are the most valuable natural products of the process—at Stockton. The volatile ammonia can be recovered in full in modern gas producers; some steam is required for that purpose, but Mr. Rambush obtained the same ammonia yield with 1 lb. of steam per pound of coal gasified as with the 2¼ lb. formerly considered necessary for that purpose. Coming finally to the question of suitable plant Mr. Rambush limited himself to recommending large gasification areas for fuels of fine grading, mechanical stirring for caking fuels, mechanical stokers for fuels of high ash content, low-temperature gasification for high yields of tar oils, and deep fuel beds for coal of high moisture.

The different conditions as to tar production, with which we have to reckon in the producer and in the laboratory retort, were dwelt upon by Dr. Colman during the discussion, as we have pointed out already; nobody has yet seen the original distillation products of coal. Dr. Lessing referred to the grading and the probable loss of the fusain, which is rich in mineral matter, by the sifting preceding the charging of the laboratory retort.

Among the difficulties discussed was the observation, mentioned by Mr. Arthur Lynn, that there is in all producer gas tests an unaccountable loss of about 13 per cent. in the carbon balance. He had in one case of large scale tests found a loss of 13·6 per cent., whilst a colleague of his, making similar tests, with the same material, observed losses of 13·2 per cent. and 13·7 per cent. In other instances Mr. Lynn could not account for the loss of 12 per cent. of the carbon, though he weighed and measured everything. Now Mr. Rambush had also made carbon balances in his laboratory tests, and they were correct. The point was not mentioned in his paper, nor did he refer there to the influence of the fusibility of the ashes, to which Mr. W. H. Patchell directed attention, though he had determined this fusibility as well. The problems are, no doubt, complex. But all proper tests are useful, and more are needed for the study of producer reactions; even Dr. Lessing's coking tests, made with samples of 1 gramme weight in silica vessels, give valuable practical information.

TRADE UNION LAW.

The great increase in the number and strength of trade unions in recent years has been accompanied by a steady development of case law in the courts on the subject of their rights and powers. The most recent case is McCluskey and others *v.* Cole and others, which was decided by the Court of Appeal on October 20 last. It was an action at the instance of a local trade union, the Glasgow and District Glass Bottle Makers Trade Protection Society, against a national federation of trade unions, viz., the National Federation of Glass Bottle Workers. Both were unregistered trade unions. The local union (the plaintiffs) were a member of the federation (the defendants). The federation had called upon its members to vote upon a certain question, but the plaintiffs had declined to do so. The federation had then passed a resolution that the plaintiffs had forfeited their membership. The resolution purported to be carried under a rule which provided that any district union acting contrary to the standing orders by refusing to act in accordance with decisions agreed to by the conference or districts should forfeit their membership. The plaintiffs brought an action claiming a declaration that the resolution expelling them was *ultra vires* of the federation, and was void, and an injunction to restrain the federation from acting upon it. The case raised an important question under Section 4 of the Trade Union Act, 1871. That Act improved in many respects the status of trade unions at law, but Section 4 provided that nothing in the Act should enable any court to entertain any legal proceedings instituted with the object of directly enforcing certain classes of agreements, including any agreement between one trade union and another.

The defendants maintained that the action was in effect, although not in form, an action to enforce an agreement between the local union and the federation, i.e., an agreement between one trade union and another, and that the courts could not entertain it. The court upheld this contention. The Master of the Rolls said that the plaintiffs claimed to remain a member of the federation. The claim impliedly rested on an agreement between the union and the federation that the union should be a member of the federation, and he thought that an action brought to prevent the defendants from breaking this rule by expelling the union was really an action for the enforcement of the agreement. Accordingly the Trade Union Act of 1871 did not enable the courts to entertain the action. On the other hand, the Act did not prevent the court from entertaining it, and it was therefore necessary to see whether the action could be entertained at common law. The court held, however, that at least one of the objects of the federation was in restraint of trade, and therefore the federation was an illegal society at common law, and the action could not be entertained. The case forms an interesting contrast to Braithwaite *v.* The Amalgamated Society of Carpenters and Joiners, which was discussed in our columns on June 17, 1921.

Another trade union litigation was added to the list on November 3, when Mr. Justice Sargant decided a case (Fowler and others *v.* Kibble and another) in which the plaintiffs tried vainly in respect of special circumstances to get protection from the court against interference with their right to dispose of their labour, despite the provisions of the Trade Disputes Act, 1906.

The plaintiffs were 10 miners who had been employed by the Cannock and Leacroft Colliery Company, Limited. They were members of a local trade union which was not recognised by the Miners' Federation. The defendants were officials of the Cannock Chase Miners' Association, which was affiliated to the federation. It appears that the defendants objected to the plaintiffs being employed at the colliery because they were not members of a recognised union. The methods which they took to enforce the objection created the special circumstances of the case. To state the matter shortly: On different occasions when certain of the plaintiffs were in the lamp queue one or other of the defendants told or advised the lamp man not to give them lamps. The lamp man did not give the lamps, and the plaintiffs were unable to go down the pit. They alleged that on their applying to the assistant manager of the colliery, the assistant manager refused to interfere, on the ground that he could not have the pit held up for the sake of a few men.

The plaintiffs claimed damages and an injunction restraining the defendants from interfering or attempting to interfere with the right of the plaintiffs to dispose of their labour as they wished with the colliery company. The defendants pleaded that all the acts done by them with reference to the plaintiffs were done in contemplation or furtherance of a trade dispute within the meaning of the Trade Disputes Act, 1906, and that they were consequently protected by the Act. Apart from the special circumstances referred to, it was clear on the authority of certain of the cases which have been noted in our columns that the defendants were entitled to the protection of the Trade Disputes Act, but the plaintiffs maintained that the defendants, by preventing them from obtaining lamps, had contravened the provisions of the Conspiracy and Protection of Property Act, 1875, and had thereby committed a criminal act which could not be protected by the Trade Disputes Act. They relied on Section 7 of the Conspiracy Act, 1875, which is to the effect that every person who, with a view to compel any other person to abstain from doing any act which such other person has a legal right to do, wrongfully and without legal authority . . . . hides any tools, clothes or other property owned or used by such other person, or deprives him of or hinders him in the use thereof . . . . shall on conviction . . . . . be liable to

certain penalties or to imprisonment with or without hard labour.

Mr. Justice Sargant found it unnecessary to decide what would be the effect of a conflict between the Conspiracy Act and the Trade Disputes Act, because he was of opinion that what the defendants did was merely to point out to the lamp man that the plaintiffs were not entitled to get lamps or work underground as they were not members of the Miners' Federation. They had no power to give orders to the lamp man, but the lamp man no doubt knew of the arrangement between the recognised unions and the Employers' Association for the employment of members of the recognised unions alone. His lordship thought that the section of the Conspiracy Act was directed to preventing a deprivation or hindrance more nearly amounting to physical violence or the threat of physical violence than had occurred on the occasions complained of, and he came to the conclusion that the defendants were not in breach of the Conspiracy Act and were protected by the Trade Disputes Act. The action accordingly failed.

THE MOTOR SHOW.

As was the case last year, the annual exhibition of motor cars organised by the Society of Motor Manufacturers and Traders, which opened last Friday, is housed partly at Olympia and partly at the White City. There are altogether 571 exhibitors this year, an increase of 52 over last year's record, and although the numerical preponderance of stands remains with Olympia, if the gallery exhibits at the latter site are not counted, the White City section of the show easily leads in magnitude. The aggregate size of the collection of motor cars and accessories, to say nothing of the motor boats and their accessories, which have a small hall to themselves at the White City, quite precludes anything but a most cursory inspection of the whole show on the part of the general public. This may not matter in so far as it affects those who merely regard the exhibition as a fashionable parade ground, but it is probable that thousands of potential purchasers will also be debarred by sheer fatigue or want of time from examining both sections of the show. If only the promoters had done a little more to classify the exhibits, and to arrange that all those of a kindred nature were grouped together, the inconvenience of having to travel from West Kensington to Shepherd's Bush to make a comparison of articles of the same type could easily have been avoided. Here and there one can trace evidences that segregation of similar articles was in the minds of the organisers, but for all practical purposes there is no effective attempt to make things convenient for purchasers having limited time at their disposal.

One cannot help thinking that business would have been facilitated—and this after all is the object of the exhibition—if the organisers had arranged, for example, that all tyres, or ignition appliances, or other accessories had been confined either to one building or to the other, and had been displayed on neighbouring stands. There should also be some system about the car exhibits, such as their arrangement in a continuous series according to power, or chassis price, or other easily understood feature. Probably the most convenient classification of the cars would be in the order of the price of the chassis. The thought uppermost in the mind of the average purchaser is not the power that he wants in a car, but the price that he can afford to pay. Classification according to price would enable him to go at once to the section where the cars within his means were assembled, and would greatly facilitate his decision as to the most suitable vehicle.

At present there appears to be no adequate system of classification, and the possible purchaser of a light two-seater, for example, has to make his way from one exhibit to another through stagnant crowds gazing at the lordly vehicles of millionaires, and then, if he is sufficiently energetic, he must travel a mile and a-half and repeat the exhausting process. The conditions are not conducive to business, or to the efficient use of time which is the essence of business, and we hope the Society of Motor Manufacturers and Traders will recognise this, and do more next year to enable every class of prospective buyer, whether of 40-h.p. limousines or of sparking plugs, to find the stands which interest them all together within a definite area, so that they can visit them without interfering with the people who want to see something else.

There is, however, another, and much more important, service which the Society of Motor Manufacturers and Traders could render to their industry by means of these annual shows. We are told over and over again that high cost of production is the cramping influence in the British car trade, and that nothing but manufacturing standard designs on a large scale will enable us to compete with the imported American cars. These statements are true, and it is equally true that no firm can manufacture a multiplicity of models with anything like the efficiency that they could attain if they devoted their energies to the production of a single type. The provision of different jigs, tools and components, and the troubles arising from more than one kind of work going through a repetition shop at the same time are matters which are well known by engineers to have a very serious influence on the cost of manufacture. Everyone nowadays pays lip-service to standardisation, and its necessity in the motor-car trade was emphasised in Mr. George Watson's presidential address to the Institution of Automobile Engineers recently. But the lesson even now has not been sufficiently taken to heart by manufacturers. If the Society of Motor Manufacturers and Traders were to prohibit any exhibitor from showing more than one model at Olympia, more would be done for the elimination of superfluous types than by any amount of exhortation. Such action would have a noticeable effect in discouraging the manufacture of numerous types by a single firm, and it would compel the makers to concentrate their attention on the type which they really wished to sell. It would also bring the size of the exhibition within much more manageable dimensions, and possibly enable the whole of the cars to be displayed in a single building, to the great convenience of the public, and no doubt also to the benefit of exhibitors.

The failure of manufacturers to concentrate upon the efficient production of a single approved type of chassis must be responsible for no small part of the difficulties in which the motor industry finds itself to-day. We find several firms at Olympia exhibiting no less than four sizes of cars. One firm provides engine powers of 25 h.p., 16 h.p., 14 h.p. and 8 h.p., another of 20 h.p., 15 h.p. 10 h.p. and 7 h.p., and so on. Now if the transmission gear, &c., are built in proportion to the engine powers we have, in the first case the absurd spectacle of two entirely different machines differing only, for practical purposes, in the fact that one of them is made to develop and transmit 2 h.p. more than the other. If, on the other hand, the transmission gears, &c., are the same, the absurdity of building two four-cylinder engines, differing as these do both in cylinder diameter and in stroke, for almost equal powers, is even more apparent. Another firm shows two chassis, rated respectively at 10/12 h.p. and 9·8 h.p., both with four-cylinder engines differing both in bore and stroke. Still another exhibitor has two chassis with engines differing both in bore and stroke, rated respectively at 10 h.p. and 12 h.p. From the engineering point of view nothing can justify this kind of thing, and manufacturers who persist in doing it deserve the inevitable troubles which they bring upon themselves. Its discouragement by the refusal of the Society of Motor Manufacturers and Traders to permit any firm to show more than one chassis at Olympia would be for the good of the industry in general and of the erring firms in particular.

The direct advantages of restricting its energies to the production of a single type of chassis could be reaped at once by every firm which decided to do so, but standardisation in other directions is also urgently needed. We refer to the question of standardisation of parts, which is a matter that can only be brought about by some central authority to whose decisions the manufacturers will conform. A very brief study of the catalogue of the present exhibition shows that there are engines on view whose cylinders have the following diameters in millimetres: 50, 55, 57, 60, 62, 63, 63·5, 65, 66, 67, 68, 69, 69·5, 70, 71, 72, 75, 75·4, 76, 80, 82, 83, 84, 85, 85·5, 85·7, 86, 88·9, 89, 90, 91·5, 94, 95, 98, 100. We do not pretend that this list is exhaustive, and it excludes all engines whose cylinder dimensions are given in inches. It is nevertheless enough to make one realise the state of the motor industry. But it does not reveal the worst by any means. Examination shows that engines with 85 mm. cylinders, for example, are built with eight different lengths of stroke ranging from 85 mm. to 130 mm.; engines with 80-mm. bore, are built with five lengths of stroke ranging from 100 mm. to 150 mm., and so on. The multiplicity of piston sizes and strokes forbids the wholesale manufacture of such c mponents as pistons, rings, gudgeon pins connecting rods and even crankshafts by firms which might otherwise lay themselves out specially for the market in such things. They have now to be made in scores where they ought to be manufactured in thousands, and the cost is, of course, correspondingly greater. Even in the rare cases in which different makers have adopted the same bore and stroke for their engines, examination would almost certainly show differences in length of piston, size and position of gudgeon pin, piston rings, &c., so that even here there is no real similarity of the parts.

We believe it would be in the interests of design if exhibitors were required to state in the catalogue the weight of every chassis shown. One of the reasons why British built cars cannot in general compete in price with American productions of the cheaper class is the great amount of unnecessary metal many of our designers employ in the chassis. Every pound of useless metal not only costs money to provide and fabricate, but it is also so much dead weight which has to be hauled about the country. It wastes fuel, and increases maintenance costs to no purpose whatever, and although a motor car need not compete with an aeroplane in lightness, neither should it emulate the functions of a road roller. A comparison of the chassis weights for cars of equal duty would reveal much to the designer, and compel him to consider the merits of alternative designs from this point of view. It would also provide edification for the general public concerning a feature which has a decided bearing upon selling price, running expenses and cost of upkeep. We pointed out last year, when commenting upon the previous show, that American cars which have proved perfectly reliable do not weigh, including the bodywork, more than 3 cwt. or 4 cwt. per passenger carried, and to compete with them the British vehicle must get down to the same order of lightness. A heavy car is not necessarily stronger than a lighter one, and its steering gear, brakes and other important parts are subjected to greater forces on account of the increased inertia. The contention that extra weight makes for easier riding has a certain measure of truth, but it does not make for cheaper riding, and the proportion of light American cars on our roads is sufficient evidence that they are comfortable enough for a very large section of the public. The exhibition will close to-morrow, November 12.

THE ELIMINATION OF OILFIELD WASTE.

Oilfields do not look attractive on photographs, and the sight and smell of oil are offensive to the casual visitor. To the critical observer the losses of oil are a matter of serious concern. It is so difficult, however, to discriminate between legitimate or excusable loss and unjustifiable waste that Mr. A. Beeby Thompson, discoursing on "The Elimination of Oilfield Waste" before the Institution of Petroleum Technologists last Tuesday, had hesitated whether he ought to speak of loss or of waste in the title of his paper. To some of us the whole reckless manner in which the present generation depletes Nature's oil resources whilst fully aware of their limitations, is stupidly selfish waste, ethically unjustifiable. Others would, at any rate, vigorously restrict the uses of oil in the interests of economy and ethics. But there are no ethics in the oilfield, and it would be more difficult to introduce them there than to drill. A man may or may

not be entitled to the gold, lead, or coal in his grounds; by mining them he does, at any rate, not directly harm his neighbour, into whose grounds the ores extend. The oil miner knows that, by sinking a new well, he may deprive his neighbour of what the latter had regarded as his oil, and the State can do little to guard individual interests. That lies at the bottom of a great many of the general sources of oil waste, with which Mr. Beeby Thompson dealt. Whatever is done on one claim may injure another.

On some of Mr. Thompson's photographs from Burmah, Rumania, &c., derrick literally crowds derrick. The multiplicity of steam, water, oil and gas mains is positively ludicrous. When a new claim is opened up, the whole system may have to be relaid. In Burmah hereditary ownership limits a claim to a diameter of 60 ft.; in Baku 92 wells have been sunk on a 27-acre plot. Co-operation in power and light generation plants, in water supply, vacuum plant, gas extraction, pipe lines, etc., would result in incalculable savings. But spirited rivalry stands in the way, and one cannot wonder. The 27-acre plot mentioned has yielded 60,000,000 barrels of oil, which would form a lake of similar area 287 ft. deep; that oil must have come from neighbouring properties. Competitive drilling discourages cautious operations; even with the greatest caution and judicious skill, however, the oil miner risks stupendous losses from outbursts of oil and gas, and constant big losses in ordinary operations

On the other hand he knows that he can hardly raise more than a small fraction of the oil actually accumulated down below. In Pennsylvania exhausted fields are now redrilled with success. J. O. Lewis, of the United States Bureau of Mines, has made some very careful inquiries into the possible and the actual yields of many oil and gas fields. Not many oil sands capable of a saturation of 10 per cent. or even 20 per cent. have yielded 3 per cent. of that oil. Various means, risky often, are employed to stimulate further production. The oil strata are washed with water, hot if possible; Nature has shown us the way, and also the risks we run by forcing the oil into new ground. A vacuum is created in the well; the yields of oil and gas have thus been increased in Oklahoma, but air and water may likewise be drawn up, especially in faulty wells, and the favoured volatilisation of the lighter oils may lead to solidification of the wax in the oil and to clogging of the sands. Compressed air is forced into the well to be absorbed by the oil which, on sudden release of the pressure, rushes up. Torpedoing of wells has found little favour outside America. Finally there is the mining, in the proper sense, of oil by shafts and headings which Chambrier made a success, under exceptional conditions probably, at Pechelbronn, in Alsace.

That losses of oil are unavoidable during its extraction is better understood than the prevention of the losses. The control of the oil flow is difficult. Pumping is, in most cases satisfactory; but the destruction of cups causes many stoppages, and the men are too much impressed with their own experience to welcome improvements by outsiders. Where the oil is at low level and contains much sand, bailing has to be adopted; that was scientifically developed in Russia, but is little understood elsewhere. Air lifts are applicable to wells of high liquid level, large productive capacity and small diameter when water and sand in the oil make pumping impractical. Mr. Thompson had much to say in favour of swabbing, not only to clean out wells during drilling, but also for regular extraction as in Galicia, though only as a last resort; success depends upon operative detail, and as to that and the principle the discussion of the paper brought out divergent opinions.

The fuel waste in oilfields has not received much serious attention. In some fields 10 per cent. of oil raised is burnt as fuel, though gas is available, and the thermal efficiency of claim plants is usually less than 2½ per cent. For drilling, most members agreed with Mr. Thompson, steam engines remain best, as electric motors cannot deal with high excess power demands. For all other purposes electric motors are preferable, in the first instance, because they do not consume energy when not working. Oil and gas engines would be more popular if their reversing gear were more perfect. The evaporation losses, especially from light oils, are likewise high; all gas escapes, spraying and splashing involve loss of light oils, to avoid which gas traps, hermetically sealed tanks, not painted red or black, and provided with umbrellas or water sprays, and closed oil circuits are now adopted. Oilfields should be drained, and have been drained, to recover large amounts of oil accumulating. Emulsions of oil and water should not be allowed to run to waste or merely be used as fuel, but be treated to gain the oil; that can now be effectively done.

The gas waste in oil fields is, however, by far the worst waste, and the solution of that problem involves many others. Even if the gas can be caught and collected, what is to be done with it? Pipe lines carrying gas at 45 atmospheres would have to be made eight times the diameter of oil pipe lines to carry the same number of heat units, and who would risk the heavy outlay in view of the uncertainty of the supply, especially from remote regions? The same difficulty also arises in connection with the establishment of glass and cement works, and even of central electricity generating stations near the field. Nitrogen fixation plants are not in a much better position, especially since the demand for helium, which necessitated similar plants, has ceased. The production of carbon black by burning the gas with insufficient air supply is in itself wasteful, and the supply of compressed power gas (Blau gas) in steel cylinders is yet in its infancy. The manufacture of alcohol and calcium carbide, which Professor Brame, president of the Institution, proposed, hardly looks promising.

As regards this gas waste, Mr. Beeby Thompson had no practical remedy to offer, whilst his paper was most instructive and suggestive with respect to the possible and necessary suppression of other sources of waste and nuisances in the oilfield. The Governments must take the risks that companies decline and provide for lower profit-earning installations which would reduce waste, Mr. Thompson had said in his introduction. He did not carry the argument further, nor did any member during the discussion. If, however, State control of an industry be justifiable at all, it would be in the exploitation of the oil wealth of the country, especially in perfectly new fields.

NOTES.

The Society of Motor Manufacturers and Traders.

The annual dinner of this society was held in the Connaught Rooms, Great Queen-street, on Thursday, November 3, the president, Mr. A. S. Mays Smith, being in the chair. In proposing the health of the motor industry, Sir William Joynson Hicks, Bart., M.P., reviewed the history of British motoring during the last quarter of a century, pointing out that although we had now one motor vehicle to every 49 of the population, in America the rate was 1 to 11. The industry made a special contribution of 10,000,000*l.* annually for the improvement of the roads, and those who bore this taxation should see that really adequate roads were provided. The new roads round London were supposed to be 120 ft. wide, but they were being constructed only 40 ft. wide, with a promise of an ultimate width of 80 ft. at some future time. In the speaker's opinion, when once they were built it would be practically impossible ever to get them widened. Good legislation was another necessity for the industry, and there was some hope of getting rid of the artificial speed limit in open country, and of replacing this by strict regulations against dangerous driving. The industry was suffering from internal divergences of outlook, and all the component organisations ought to come together and elect a representative body who would speak authoritatively as to their needs. The president, in replying, stated that the Society of Motor Manufacturers and Traders, which fell to 578 members during the war now had a membership of 1,090 firms. Industry throughout the country was in a precarious condition, but no Government in the world could do much to help it to its feet again so long as employers and employed were pulling in different directions. Mr. H. G. Burford, M.I.Mech.E., M.I.A.E., vice-president, heartily endorsed the suggestion that all associations and societies connected with motoring should co-operate and show a united front in presenting the views of the industry.

The Thomas Hawksley Lecture.

The Thomas Hawksley Lecture was delivered at the Institution of Mechanical Engineers, Storey's Gate, St. James' Park, on Friday last, the 4th inst., by Dr. H. S. Hele-Shaw, F.R.S. The subject taken at these lectures as the president, Captain H. Riall Sankey, C.B., C.B.E., in introducing the lecturer explained, originally dealt with hydraulic matters, though it was not intended that they should be altogether restricted to these. Dr. Hele-Shaw made an excursion out of the usual field, and dealt with the "Transmission of Power by Oil." We think everyone will agree with Mr. Michael Longridge, to whom it fell subsequently to propose a vote of thanks, that the lecturer had taken a great deal of pains to make his subject an interesting one, and that he was successful in his efforts was evident from the cordiality with which the vote was passed. The lecture was well illustrated by models and parts of machines, lantern slides and lantern experiments. As it was to be re-delivered in Manchester yesterday, and later in Birmingham and Glasgow, we are precluded in accordance with the custom of the Institution from giving a full report of it. Briefly, Dr. Hele-Shaw divided his lecture into sections of which the first dealt with the mechanism of oil transmission; the second received causes militating against the use of working fluids, while the third was devoted to a discussion of the characteristics of oil, and the features to which in this connection its adoption owed success. The mechanisms described included both the radial plunger, and the swash plate types of pump. The method of control of both types was explained by means of interesting models, and the efficiency obtained with such gears was discussed. The lecturer subsequently dealt with the advantages of oil from the point of view of corrosion, and went on to discuss slip and viscosity at the high pressures and speeds used in the mechanisms described. The question of compressibility was also touched upon, and the effect of the thickness of films of lubricant was illustrated by means of demonstrations on the screen. Finally, the lecturer concluded with illustrations of a number of applications of the system, ranging through presses, lifts, motor lorries, searchlight-control and steering gear, to the control of 6-in. guns. In the latter, one pump is provided for elevation and one for direction, and the gun can be kept on its target without any appreciable effort, whereas with the gear formerly used a strong man was exhausted after a very short space. Dr. Hele-Shaw expressed the hope that the Institution might see its way to take up the unsolved problems of lubrication as a research subject.

Motor Vehicle Lights.

The introduction of the acetylene lamp made cycling at night both safer and more pleasant for the rider, but greatly increased the risks incurred by other road users, the pupils of whose eyes, expanded to their utmost in the endeavour to pierce the surrounding gloom, were, suddenly contracted by the brilliant headlight of the approaching cyclist. The wayfarer thus encountered was rendered practically blind for many subsequent seconds. Electric headlights have proved just as dazzling, and the rapid increase in the number of motor cars thus furnished and the protests thereby occasioned led the Ministry of Transport to appoint a Departmental Committee to report upon the whole question. In the third interim report* just issued this committee observe that they have satisfied themselves that the complete elimination of dazzle under all conditions is inconsistent with the retention of a safe driving light, and that the matter is accordingly one for compromise. In the course of their inquiry the committee have examined over 100 lamps and devices for eliminating dazzle, and of these the most promising have been tested not only in the laboratory but also on the road. None of the plans proposed for eliminating dazzle from

* Third interim report of the Departmental Committee on Lights on Vehicles. 1921. H.M. Stationery Office. Price 6d. net.

existing lamps have been found of value as they reduce the light too much to make driving safe, but certain new designs of lamp are reputed to show a reasonable prospect of eventually affording a satisfactory solution of the problem. The driving light proposed by the committee consists of a main beam restricted in its height to 4 ft. above ground level, supplemented by a secondary light giving a certain general illumination around the vehicle, and they also speak with approval of the plan adopted in some cases by which the driver can on approaching other wayfarers tilt down his beam below its normal level. For the guidance of lamp makers the following specification has been drawn up: There should be a main beam of light having (*a*) A minimum range of forward illumination of 150 ft. and a maximum of 300 ft.; (*b*) a minimum width of 30 ft. with a maximum height of 4 ft. from the ground at 150 ft. from the lamp; (*c*) the lower edges impinging upon the road not more than 50 ft. from the face of the headlight; (*d*) the field free from dark patches and the illumination reasonably uniform or having good gradation. In addition to the main beam there should be a field of diffused light with a range of forward illumination not exceeding 50 ft. or less than 25 ft., with a lateral diversion at the road surface of at least 20 ft., at a distance of 5 ft. forward from the face of the lamp. It is suggested that lamps constructed in accordance with this specification shall be certified, and that vehicles equipped with such lamps shall *prima facie* be considered as complying with any regulations for the avoidance of dazzle.

Trade with Canada.

It is somewhat refreshing in these gloomy days of trade depression to find an optimistic note struck in an official document, backed by encouraging figures. We have frequently insisted upon the opening which exists for British goods in Canada, if only our manufacturers will bestir themselves and snatch the opportunity instead of letting others seize it. A statement has just been issued by the Department of Overseas Trade, emanating from His Majesty's Trade Commissioner in Winnipeg, Mr. L. B. Beale, which supports this view, and in addition offers some facts which go to show that our country is becoming alive to the advantages of offering Canada what it wants on terms which compare favourably with those on which she does business with the United States. The report has to do with conditions as they existed in October, and many of the statistics relate to the 1920 period, but nevertheless they indicate considerable possibilities, making every allowance for the changes of the last few weeks, and in view of the certainty that the present depression must be followed in time by renewed activity. The Commissioner states that we are now securing trade in Canada in lines never before exported to that country, and in which the United States practically had a monopoly. Importing traders are said to be greatly pleased with the success, and "would welcome still more aggressive methods on our part, which undoubtedly would reap the reward of greatly increased business." Although things are quiet at the moment, the grain harvest and fruit crop will induce a good deal of buying, not quite, perhaps, to a normal degree. There are indications that the most difficult period is over; commercial failures and liabilities indicate a slight improvement, while unemployment has also shown a slight decrease. It is pointed out that now is the time to get a footing in the country, before the custom again starts flowing in channels towards the United States, from which it would be difficult later to deflect it. It is interesting to note the changes indicated in the latest statistics available, namely, the four months of 1921, ending with July. In this period Canada imported from us iron and steel products to the value of 3,151,580 dols. This, it is true, is less than 9 per cent. of the imports of this class from the United States into Canada, but the significance of the figure lies in the fact that it is an increase of over 50 per cent. on the imports from us in July, 1919, whereas the United States trade now is 33⅓ per cent less than what it was then. It is not wise to lay too much stress in these days of violent fluctuations on figures for short periods, but the relative changes certainly seem to indicate improvement in the commercial activities between the Dominion and the Home Country, which seems to be winning back some of the trade it has allowed to drift to the United States through lack of enterprise. Considering still the same two periods, our trade in razors shows an increase of 100 per cent., while in this item that of the United States has fallen to one-fifth of its former value. But why in this two years interval should our manufacturers have allowed Germany to develop this business to the extent of nearly half our total? Again, take scissors. Our trade with Canada has more than trebled, though even now the figure is disgracefully small and completely eclipsed by that of the United States which, however, in this branch also shows a decline. Here again the reappearance of Germany is notable for the development in two years of trade exceeding ours by half as much again. In pocket knives we have clearly obtained a good footing. In this year's period our trade was 7½ times as large as in 1919, while that of the United States was only a quarter as large. Here, again, Germany on re-entering this market has secured business in two years equal to what we held in 1919. Clearly although there is a tendency for trade to come here if we encourage it, severe competition with German as well as United States goods, will have to be faced.

Export of Vessels from Sweden.—The export of Swedish tonnage during the elapsed portion of the present year has assumed very large proportions, according to *Swedish Export*. The total amount of tonnage exported down to the middle of September is 62,493 tons gross. The gross tonnage sold to Germany is 54,621, to Norway 2,552, to Finland 1,397, to England 1,174, to Mauritius 1,259, to Denmark 777, to Esthland 395, to Iceland 191, and to Spain 127. The Swedish Government has further granted licences to export a total amount of 30,162 tons gross.

Uses for Slate Dust.—The United States Bureau of Mines have recently issued serial report No. 2,283 dealing with the results of an investigation into the utilisation of waste slate as a "filler" in connection with the manufacture of rubber, linoleum, paper, paint, &c. The complete report should be studied by those interested. It is summarised as follows: "All of the information available indicates that waste slate may be used to advantage as a filler in mechanical rubber goods, and in some classes of oilcloths, floor coverings and window shades. Apparently it is not adapted for use in rubbers of a grade used in automobile tyres. For plastic roofing and flooring products containing coal tar it has long been in use and constitutes a very satisfactory filler. For some products, particularly for rubber, a much finer-grained slate flour than any now on the market is demanded. One of the most promising ways in which manufacturers of pulverised slate can promote a wider use of slate flour is by producing a uniform reliable product, at least 95 per cent. of which will pass a 300-mesh screen, and by introducing such a product among manufacturers of mechanical rubber goods, linoleum oil cloth, phonograph records and other products requiring an extremely fine-grained filler."

Industrial Respirators.—The "puretha" respirator which was recently described by Dr. L. Levy and Mr. D. W. West before the Society of Chemical Industry (Journal of the Society, October 15), is provided with the special face piece of Mr. Rosling. It is made of fairly thick rubber and fabric, and attached to the head by an adjustable elastic harness composed of four tapes; the area of contact being large, the discomfort caused by the face piece to the wearer is said to be small. The box respirators are filled with crystalline copper sulphate to absorb ammonia, with charcoal for all sorts of chemically neutral fumes (hydrocarbons, &c.) and with alkaline granules for acid fumes; these granules are composed of slaked lime, kieselguhr, ferric hydroxide and activated charcoal. For carbon monoxide the "hoolamite" of the United States Bureau of Mines (iodine pentoxide and fuming sulphuric acid on pumice grains) is used, not merely as a detector, as in America, but as an absorbent. The idea is that any CO present will liberate iodine which, irritating the eye and nose of the wearer, gives warning. To keep off irritating dust the respirator is combined with filtering pads as in the Army masks. During the discussion of the paper objection was taken to the liberation of the iodine; but Dr. Levy assured members that the irritation would pass in 10 minutes or so. More serious was the point raised by Dr. T. M. Legge, H.M. Factory Inspector, that most breathing apparatus were death-traps to the untrained worker. In works the danger was generally not continuous, as in war at the front, but incidental and unexpected, and it was very difficult to discipline workers in the factory. Hence only the simplest apparatus had been approved by the Mines Rescue Apparatus Committee, and he asked what advantages these apparatus offered over the Siebe-Gorman Gasman respirator. Most members agreed that it was best to do without respirators, especially when different respirators were to be used for different atmospheres, and to provide for efficient ventilation.

The Cleary Oil Burner.

A very successful demonstration of the Cleary oil burner and its application to domestic heating, lighting and cooking was given on Friday last by the British Petroleum Company, Limited, of 22, Fenchurch-street, London, E.C. 3, who are the sole agents in the United Kingdom and India for these burners and for the various appliances of which they form the essential part. The burner, which is the invention of Mr. Edwin Cleary, uses ordinary lamp oil, or kerosene, and produces a high temperature, blue, smokeless flame which can be turned up or down at will in the same way that a gas ring can be regulated.

The burner is mounted on an oil reservoir fitted with a small air pump which is used to force the oil up into the vaporiser in the usual way. The vaporiser is a small vertical tube, the upper end of which is heated by the flame, and the vaporising effect is considerably increased by the fact that the tube is partially filled with nickel wire gauze. The latter serves to conduct the heat downwards, so that as the oil rises it is subjected to an increasing temperature The oil vapour first passes round a passage in a disc-shaped casting mounted on top of the vaporiser, and afterwards descends through a plain vertical tube to a jet. From the jet the highly-heated oil vapour is directed upwards through a depending sleeve, drawing air in with it, and the mixture, after being further heated in a flat cylindrical box at the top of the burner, escapes around the periphery of the box, where it burns almost silently. The flow of vapour from the jet is controlled by means of a valve including a pricker which passes out through the jet each time the valve is closed, so keeping it free from obstruction.

The burner, as above described, can be used for boiling and other domestic heating and cooking operations, but it can also be used for lighting by means of a special fitting supplied to carry an incandescent mantle. A larger burner is made for similar purposes and also for heating a specially-designed cooking oven surmounted by a *bain-marie* accommodating four saucepans. The larger burner is also arranged for heating rooms, a sheet-metal casing, containing a copper reflector, being used for this purpose. The burner is started by burning a small quantity of methylated spirit in a cup fixed near the base of the burner, a metal sleeve being provided to protect the flame from draughts and to direct it up around the vaporiser.

The whole design seems to have been very carefully worked out, and the resulting products appear to us to be well suited for the purposes for which they are supplied. The small burner, we are informed, will burn for 8 hours with a consumption of 1 pint of oil, while the average consumption of the larger burner is about twice as great. No attention need be given to the burner while in use, except that the pump requires a few strokes at intervals of about 3 hours.

Although mainly intended for domestic use, the burners, we believe, could easily be adapted for numerous workshop and other technical applications by providing them with a rather heavier oil container.

The late Lieutenant-Colonel P. G. von Donop.—We regret to have to record the death in London, on Monday, of Lieutenant-Colonel Pelham George von Donop, who was formerly so well known for his connection with the Board of Trade inquiries into railway accidents. Pelham von Donop was born in April, 1851, being the son of Vice-Admiral E. P. B. von Donop. His early education was received at Somerset College, Bath, and in 1871 he obtained a commission in the Royal Engineers. His subsequent promotions were to captain in 1883, major 1890, lieutenant-colonel 1897. During his service, in the years 1889–92, he was Inspector of Submarine Defences in India. In 1899 he was appointed Inspecting Officer of Railways under the Board of Trade, and after fourteen years service as such, was appointed Chief Inspector in 1913, which position he held till 1916, when he retired from active work.

Rustless Plastic Steel.—Messrs. Samuel Osborn and Co., Limited, Clyde Steel Works, Sheffield, inform us that they have carried out successfully a series of experiments with a view to producing a steel which, whilst having thorough rust-resisting properties, can be easily worked both in the hot and in the cold state. As a result of these experiments they have placed on the market "Osborn's Rustless Plastic Steel." This can be stamped, punched, pressed, chased or engraved cold, and can be bent cold to a diameter equalling its own thickness without showing signs of fracture. It may be polished silver bright, the high polish being retained after being worked cold. This polish is also retained in any atmosphere. In many cases, a piece made of this steel has less than half the weight of a brass or nickel piece, whilst being of the same strength. The steel is supplied in bars of numerous sections, in sheets 20 gauge and thicker, also as castings.

INDUSTRIAL NOTES.

The late coal strike has left the coal-mining industry throughout the country in a most difficult situation; it has had for one result the cessation of the demand for industrial coal and the stoppage of most of the metallurgical and engineering works, a stoppage which still continues. A large number of miners—175,000, it is stated—are now unemployed, and three-quarters of those who are still in employment are on short time. The situation and the question of wages were gone into at a conference of the Executive of the Miners' Federation which was held in London last week end, when it was decided to ask the Prime Minister to see them with a view to discussing with him mainly the fall in the miners' wages. The Prime Minister received the Executive of the Miners' Federation last Wednesday. They called his attention to the fall in the earnings of both the underground and the surface workmen, a fall amounting to from 7*s.* to 9*s.* per day. These earnings, they said, showed an actual rate per hour of 1*s.* in certain instances for skilled colliers, and as low as 8*d.* per hour for some surface workmen. Moreover, not more than 3·9 shifts per week were being worked on the average throughout the country, and at some individual collieries not more than two shifts per week. The Federation therefore expected that the unexpended balance, 3,000,000*l.*, of the subsidy would be utilised to supplement the wages, and that the Government would adopt such means as were within its power to restore normal production of coal. The Prime Minister replied that he recognised the very serious situation in which many of the miners found themselves. The appeal had been fully considered by the Cabinet, and it had come to the conclusion that it was not possible to aid the coal industry in the way suggested. The 3,000,000*l.* had not been voted by the House of Commons, and it would have to be borrowed by the Chancellor. It was not lying in the Treasury. A proposal to borrow this sum was one which the Government could not make to the House and, if made, was certainly not one to which the House would agree. He reminded the Executive of the costly measures already taken to relieve unemployment. There were faint indications of a revival of trade. That revival would only come by honestly facing the facts; it would be retarded and not advanced by measures which added to the national indebtedness.

In this connection we may add that Part 2 of the Mining Industry Act, passed in August, 1920, has come into prominence during the last few days. This provided for the constitution of a system of committees and boards for the regulation of wages and conditions of work in the industry. The miners disliked the scheme and said they would not work Part 2. Following this, a clause was inserted in the Act stating that if at the end of one year from the passing of the said Act, Part 2 had been rendered abortive by the non-appointment of representatives on the committees and boards, the Board of Trade should issue a report to Parliament, and that unless Parliament within 30 days otherwise determined, Part 2 should cease to have effect. With reference to this, Mr. Evan Williams, president of the Mining Association of Great Britain, has stated that this association has requested the Board of Trade to take the necessary action by reporting to Parliament that Part 2 is abortive. He added that since an arrangement had recently been reached for dividing the proceeds of the coal industry among the coalowners and the miners, it was felt that further Government action between the two was against the best interests of the industry. There were, moreover, in existence at the present time other arrangements of a voluntary nature for discussing questions which arose, and further voluntary arrangements could be entered into if necessary. Mr. Bridgeman, the Secretary for Mines, has stated that he is not in agreement with the Mining Association on the point.

Representatives of the Trades Union Congress, the Labour Party and the Parliamentary Labour Party, it is reported, have written the Prime Minister opposing the intended abolition of the Ministry of Transport. They state that its abolition would render the country less able to meet foreign competition in commerce and industry, since a number of transport problems can only be efficiently dealt with by the head of a department having Ministerial authority and responsibility, and thereby able to exercise initiative and discretion.

The report on the economic and commercial situation of Australia to June, 1921, by Mr. S. W. B. McGregor, H.M. Senior Trade Commissioner in the Commonwealth of Australia, states that there has been considerable labour unrest during the year in Australia, as in other countries. A stewards' strike paralysed the coastal shipping service from December 14, 1920, to February 28, 1921, causing serious public inconvenience and heavy indirect losses. The strike at the Broken Hill mines commenced on May 4, 1919, and terminated on November 10, 1920. The statistics in connection with industrial disputes are as follow:—

	Number of Working Days Lost.	Total Estimated Loss in Wages. £
1917	4,599,658	2,594,808
1918	580,853	372,334
1919	5,662,736	3,492,936
1920	3,587,367	2,370,367

The policy of strict economy in expenditure was continued during the year. No works of any magnitude appear to be practicable, for financial reasons, in the near future.

The secretary of the London Iron and Steel Exchange, Limited, dealing with the meeting held last Tuesday, says that attention has been attracted to the increased quantities of pig-iron which have been imported into this country of late. It is difficult to see, he adds, how this could have been avoided, unless the whole iron and steel industry had shut down. British pig-iron producers have signified their intention of keeping their blast furnaces cold until fuel can be purchased at a figure that will enable them to compete with foreign makers. In the meantime, the foundries, steel makers and other departments of the trade require pig-iron at a price which will enable them to carry on their operations on a basis allowing them to meet Continental competition. The natural result of this has been the increased import of pig-iron.

The following is a brief summary of the substance of the draft conventions and recommendations of the International Labour Conference at Geneva: (1) Limiting the hours of all workers in the fishing industry, with such special provisions as may be necessary to meet the conditions peculiar to each country. (2) Limiting the hours of inland navigation workers, with provision for special local conditions: agreements to be made between adjacent riparian countries. (3) Arranging international seamen's codes. (4) Fixing the minimum age for admission of children to employment at sea to 14 years, except: (*a*) Ships of war; (*b*) properly supervised training ships; (*c*) ships worked by one family only; (*d*) when local conditions contra-indicate. (5) Adoption of insurance against unemployment arising out of shipwreck or any other cause either by Government insurance or by Government subvention to suitable industrial organisation. (6) Providing that, in all cases when unemployment arises directly from the loss or foundering of a ship, the owner shall give an indemnity against unemployment up to two months' wages to each seaman employed on the ship. (7) Rendering punishable the business of finding employment for seamen if carried on for pecuniary gain, though existing agencies may continue temporarily under Government licence until committees composed equally of owners and seamen shall have set up suitable machinery.

The late Professor Carlton John Lambert.—We regret to have to announce the death, which occurred suddenly on the 6th inst., at Buckhurst Lodge, Westerham Hill, Kent, of Mr. Carlton John Lambert, M.A., Cambridge. Mr. Lambert was 77 years of age. He had been for several years professor of mathematics, physics and mechanics at the Royal Naval College, Greenwich. He was elected in 1896 an Associate Member of the Institution of Naval Architects.

"Revue de Metallurgie."—Our Paris contemporary has recently issued in book form a reprint of the series of articles it has published recently in successive issues, concerning the devastation of metallurgical works of North and North-East France. The book is admirably got up; it opens with an introduction, in French, by Professor Guillet, followed by an abstract of the same in English, Italian and Spanish, the references to the 300 illustrations being similarly translated. By this means, the book will appeal to a large circle of readers outside France. The publication forms a quarto volume of 270 pages; its price is 25 francs, and it can be obtained from the offices of the Revue, 5, Cité Pigalle, Paris, 9.

Road Rollers for Syria.—A telegram from H.M. Consul-General at Beyrout, to the Department of Overseas Trade, is to the effect that the Direction des Travaux Publics, Grand Liban, Beyrout, invites tenders for the supply of five road rollers weighing 4 tons to 6 tons on the road, having 20 b.h.p. to 30 b.h.p. oil engines with a radiator of large surface, a minimum speed of 4 km. to 5 km. per hour on a 7 per cent. incline, and a maximum speed of 7 km. per hour. They are required to be equipped with two powerful brakes, and ballast boxes made of sheet steel, having a total capacity of 1·3 cub. m. All component parts to be interchangeable. Plans and specifications, catalogues, prices and full particulars, including date of delivery, should be submitted to the Direction des Travaux Publics, Grand Liban, Beyrout, Syria. The closing date for the receipt of tenders is apparently not fixed.

INTERNATIONAL CONFERENCE ON HIGH-TENSION TRANSMISSION SYSTEMS.

The Union des Syndicats de l'Electricité, of which Mr. Tribot Laspierre is the general secretary, has invited the following countries to send delegates to a conference to be held in Paris to discuss the various technical problems relating to high-tension transmission systems: Great Britain, Belgium, Spain, United States, France, Holland, Italy and Switzerland.

The following delegates have been nominated by the Institution of Electrical Engineers to represent the British interests: Mr. P. V. Hunter, Mr. E. B. Wedmore and Mr. W. B. Woodhouse.

The various National Electrotechnical Committees of the International Electrotechnical Commission have been asked to do their best to assist in making this conference as representative and as successful as possible. The Union des Syndicats de l'Electricité desires it to be known that in addition to the delegates from the different countries specially nominated the meetings will be open to all engineers who wish to attend.

It is proposed that the conference should be divided into three sections dealing with (1) power station operation, including sub-stations; (2) construction of lines; and (3) distribution. It is hoped that the delegates from each country will submit papers on the subjects brought forward for discussion. The meetings will be held at the offices of the Union des Syndicats de l'Electricité, Paris, and will commence on Monday, November 21 next, continuing until Saturday, November 26. No afternoon meeting will take place on Thursday, November 24 as the celebrations in honour of Ampere will be held, which celebrations will be presided over by the President of the French Republic. Reports of the conference will be issued in French and English, and interpreters representing seven languages will be present for the purpose of translating, if necessary, the decisions arrived at. A dinner will be given to the delegates on Thursday, November 24, at the Palais d'Orsay, and a number of visits and excursions are being arranged comprising an excursion to the devastated regions in the North of France, and a visit to some of the new electrical installations already completed or in course of completion. A complete programme of the meeting can be obtained on application to the Secretary, International Electrotechnical Commission, 28, Victoria-street, S.W. 1.

British Samples, Limited.—The Federation of British Industries, 39, St. James'-street, S.W. 1, has sent us a copy of a booklet describing the first of a series of large British sample rooms which it is proposed to establish in the leading foreign commercial centres. Complete information can be obtained from the offices of the Federation.

University of Bristol.—This university has issued a pamphlet of 48 pages, containing 172 photogravures, illustrating all branches of its various activities. It is believed that this is the first attempt, either in or outside Great Britain, to convey by means of illustrations exclusively, a comprehensive idea of the work and organisation of a modern university.

Exhibition in Singapore.—With a view to stimulating a revival in trade an exhibition will be held in Singapore on the occasion of the visit of H.R.H. the Prince of Wales. The exhibition, which will be open from March 31 to April 8, 1922, will be under the auspices of the Governments of British Malaya, Borneo and Sarawak. There will be sections for Forestry, Mines, Agriculture, Arts and Commerce. The Malay States Agency, 88, Cannon-street, E.C. 4, has been asked to assist in connection with the exhibition, and hopes at an early date to issue fuller information.

"Coal Resources of the World."—We are informed that a number of sets of this work, which is a report of an inquiry made upon the initiative of the Executive Committee of the Twelfth International Congress, Canada, 1913, are still available. It consists of three quarto volumes with 1,266 pages and numerous text figures and maps, and is accompanied by an atlas of 48 maps and sections. The work, which originally sold for 25 dols., can now be had in Great Britain at a cost, inclusive of postage, of 2*l.* 12*s.* 6*d.* per set, payable in advance, by applying to the King's Printer, Ottawa, Canada.

Combined Iron and Steel.—Dr. Longmuir delivered before the Birmingham Metallurgical Society, on October 20, a lecture in which he dealt with the production and the properties of combined iron and steel. Following a sketch showing the development of welding and the production of composite steel, emphasis was laid on the fact that in the case of combined iron and steel, both the iron and the steel were melted in crucibles in the same furnace, and cooled together in the one mould from the fluid state. The working up of the ingot or "lump" down to the finished product was also reviewed. The uses for iron and steel when combined were shown to be distinctly on the increase, and ranged from the cutting of grass to the shaving of carpets, and the trimming of paper to the working on all classes of wood at very high cutting speeds. From 3,000 r.p.m. to 4,000 r.p.m. are not uncommon, and therefore the importance of intrinsic quality is evident. In the case of high-speed woodworking, the use of combined iron and steel showed economy and higher efficiency as compared with the use of solid steel. The lecturer announced that further research is in progress in the laboratories of Messrs. H. Rossell and Co., Limited, Sheffield.

DOUBLE-ACTING TWO-STAGE AIR COMPRESSOR.

CONSTRUCTED BY THE AKTIEBOLAGET ATLAS DIESEL, STOCKHOLM, SWEDEN.

(*For Description, see opposite Page.*)

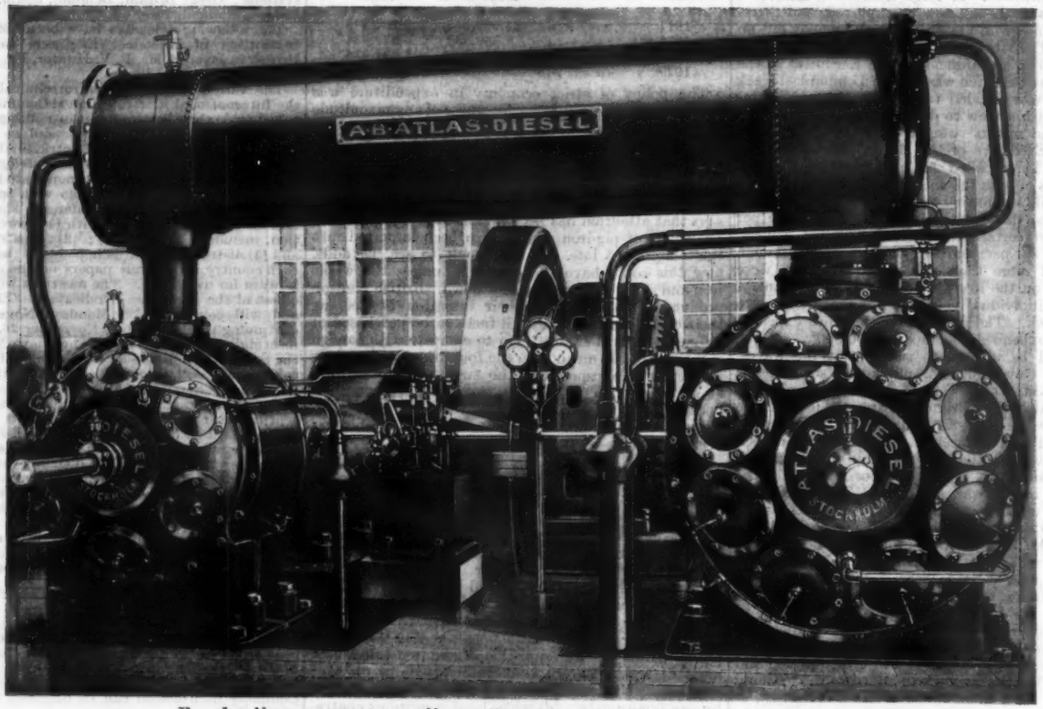


FIG. 1. VIEW SHOWING THE VALVE CHAMBERS ON THE COMPRESSION CYLINDERS.

FIG. 2.

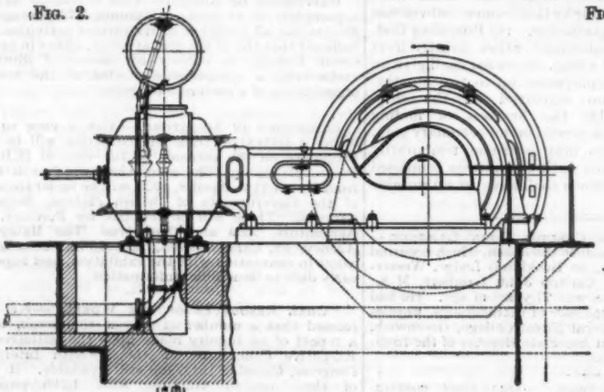


FIG. 3.

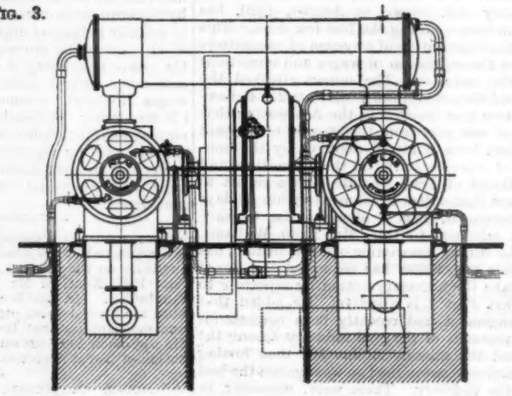


FIG. 4.

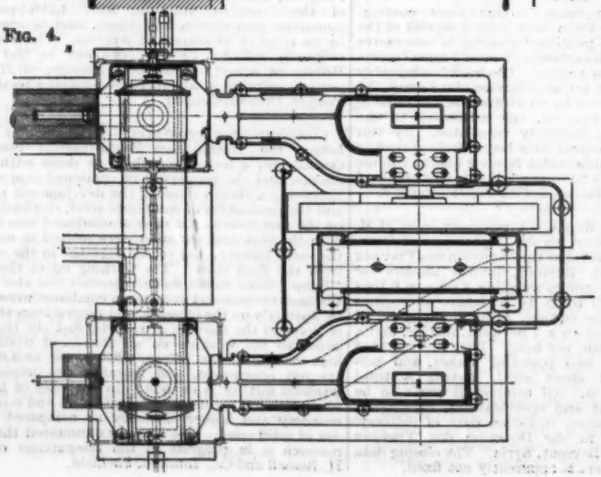
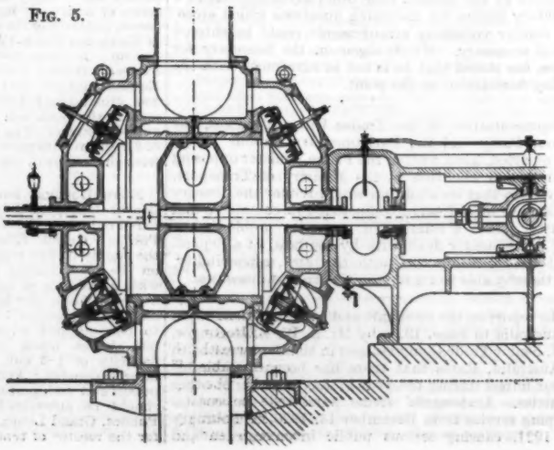


FIG. 5.



DOUBLE-ACTING TWO-STAGE AIR COMPRESSOR.

What is, we believe, the largest air compressor ever built in Sweden is illustrated on this page and opposite. It is in operation in the Kürunavaara power station of the Luossavaara - Kürunavaara Mining Corporation, and delivers compressed air to the mines. This company works iron ore mines which are situated at Malmberget and Kiruna, and some 2,400 miners are employed. The mines are among the most northerly in the world, the Kirunavaara lying on the sixty-eighth degree of latitude and twentieth degree of longitude. The present output of iron ore is about 4,000,000 tons a year, but it is hoped to increase this figure to 6,000,000 tons in the near future. The deposits are estimated at 1,000,000,000 tons. The ore consists of magnetic iron up to 70 per cent., the percentage of phosphorus varying between 0·02 per cent. and 5 per cent., and the sulphur seldom exceeding 0·05 per cent. The mining is chiefly carried out in open cuts and labour-saving machinery and tools are extensively employed.

The air compressor with which we are concerned in this description was constructed by the Aktiebolaget Atlas Diesel of Stockholm, the English representative of which is the Atlas Diesel Company, Limited, of 35, Surrey-street, Strand, W.C. 2. The compressor is of the two-cylinder, double-acting, two-stage type and is driven by a directly-coupled electric motor, the rotor of which is actually mounted on the crankshaft. The motor, which was manufactured by the Allmanna Svenska of Vesteras, operates from a three-phase, 2,000-volt. 25-period circuit, and develops 640 b.h.p. at 162·5 r.p.m. When running at this speed the compressor takes in 3,400 cub. ft. of air per minute and compresses it to 7 atmospheres. The principal dimensions of the compressor may be tabulated.

Diameter of low-pressure cylinder	34 in. (865 mm.)
Diameter of high-pressure cylinder	20 in. (515 mm.)
Stroke	23½ in. (600 mm.)
Diameter of intake pipe	15¾ in. (400 mm.)
Diameter of discharge pipe	10 in. (250 mm.)
Cooling surface of intercooler	900 sq ft (85.25 sq. m.)

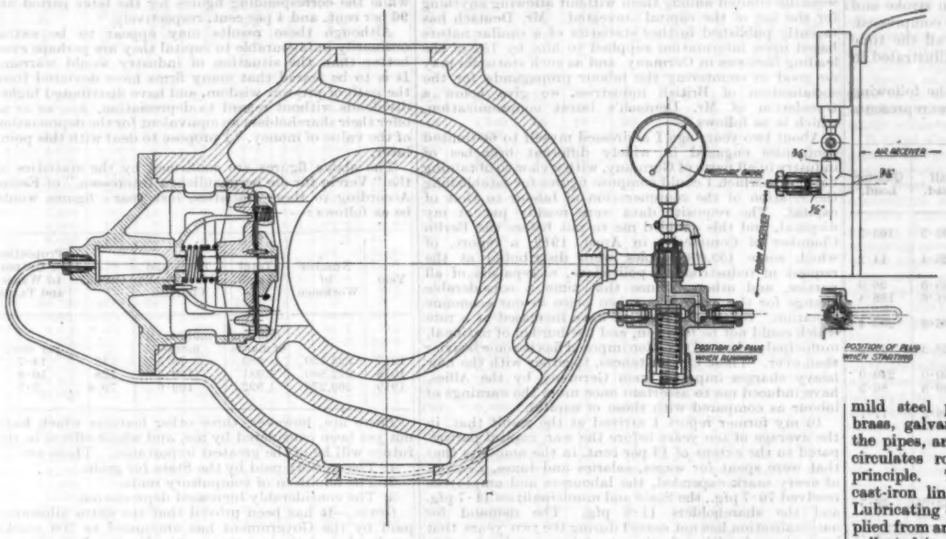


Fig. 6.

The general appearance of the machine is well shown in Fig. 1, from which it will be seen that the compression cylinders are arranged horizontally, and that the intercooler is carried overhead. Outline front and side elevations, and plan, are given in Figs. 2 to 4. The valves are of the Atlas-Rogler type, consisting of light flat steel plates perforated in such a way as to give large air passages with a very small lift. The valves are self-acting and their movement is regulated by cages. The arrangement of the valves at each end of the cylinders is shown in Fig. 5 and it will be evident that the lay-out renders them very accessible. This is also clear from Fig. 1, in which the valve chamber covers can be seen around the cylinder. Each end of the low-pressure cylinder has four inlet and four discharge valves, while in the high-pressure cylinder there are three of each type.

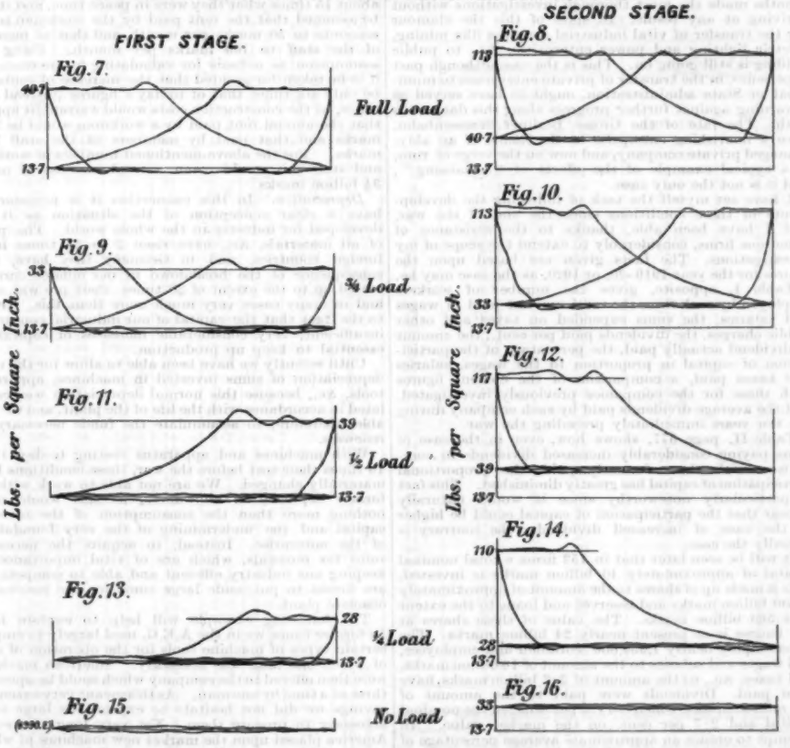
The intercooler casing is built up of mild steel plate, and the tubes are of solid drawn brass, galvanised. Cooling water circulates through the pipes, and the air from the low-pressure cylinder circulates round the tubes on the counter-current principle. The cylinders are fitted with close-grained cast-iron liners and are, of course, water-jacketted. Lubricating oil for the bearings and crossheads is supplied from an oil receiver in the crank-case. Excess oil is collected in the crankcase and returned to the receiver by means of a disc on the crank. For facilitating the adjustment of the air-gap of the motor, the main bearing boxes of the compressor are made in four parts which may be relatively adjusted by means of screws and wedges. In addition, the footplates of the stator of the motor are furnished with adjusting arrangements which allow it to be raised, lowered, or moved sideways.

One of the special features of the compressor lies in the unloading arrangement. In many plants of this kind the unloading device acts when the pressure in the air receiver, or pipe line, exceeds a definite limit, and in such a way that the intake and compression of the air stops, so that the machine runs either at no load or full load. In the present installation, however, such a large fluctuation of power demand as would occur on a sudden change from full load to no load, would cause serious disturbance on the electrical system, and the regulating device has accordingly been designed to unload in four stages. The unloading is effected gradually from full load to three-quarters load, from three-quarters load to half-load, from half-load to quarter-load and from quarter-load to no load. These changes take place without any appreciable variation of pressure between the different stages. The change from no load to full load takes places in a similar manner in stages.

The type of unloading arrangement which is used is illustrated in Fig. 6, annexed. This shows a section through one of the valves, complete with the automatic unloader. The device consists of a spring-loaded piston regulated for a certain pressure, arranged so that when this pressure is exceeded the piston moves and opens a small unloader valve which admits compressed air to a small pipe leading to the inlet valve on the compressor. This inlet valve is fitted with a piston on which the compressed air operates and, as will be seen from Fig. 6, the effect of the movement of this piston is to lift the inlet valve off it seat. The result of the arrangement is that the air which is drawn into the cylinder during the out stroke passes out again through the inlet valve on the back stroke, and no compression takes place. When the unloader ceases to operate, the inlet valve moves back to its normal position under the action of a spring, and the valve is free to perform its ordinary functions.

The method in which the progressive unloading in stages is carried out is illustrated by the series of indicator diagrams given in Figs. 7 to 16, on this page. Diagrams at full load, when the maximum amount of air is taken into the cylinders and compressed, are given in Figs. 7 and 8. The state of affairs attained at three-quarter load is indicated by Figs. 9 and 10 It will be seen from the first-stage diagrams given in Fig. 9 that at one end of the cylinder half of the air taken in on the suction stroke passes out again without being compressed on the latter half of the compression stroke. At the same time the whole of the air drawn in at the other end of the cylinder is compressed exactly

UNLOADING DIAGRAMS FOR TWO-STAGE AIR COMPRESSOR.



as on full load. The second stage remains as on full load, except that only three-quarters of the volume of air has to be dealt with. The conditions at half-load are shown in Figs. 11 and 12, from which it will be seen that both on the first and second stages the admission valve at one end of the cylinder remains open during the compression stroke, so that only half the air drawn in is discharged. At quarter load, as shown in Figs. 13 and 14, the first-stage inlet valve of the operating side remains open for half the compression stroke and only one-quarter of the air drawn in is compressed. At no load all inlet valves remain open all the time and no compression takes place. This is illustrated in Figs. 15 and 16.

In the official tests of the compressor the following results were obtained. Each series of figures represents the average of several tests :—

—	Full Load.	Three-Quarter Load.	Half Load.	Quarter Load.
Revolutions per minute..	161·3	162·5	163·5	163·5
Pressure in intercooler, pounds per square inch	26·9	19·9	25·4	14·2
Pressure in air receiver pounds per square inch	99·0	99·5	95·0	96·0
Indicated horse-power ..	581·2	467·7	301·6	186·4
Power input to motor, kilowatts	516·5	417·2	286·8	203·4
Power lost in motor, kilowatts	41·5	34·5	29·3	27·2
Power input to compressor, horse-power ..	645·5	520·0	350·0	240·0
Motor efficiency, per cent.	91·96	91·7	89·8	86·5
Compressor mechanical efficiency, per cent. ..	90·0	89·9	86·2	77·7
Volumetric efficiency (the ratio between the volume of free air measured on the indicator card and the piston displacement of the machine)	84·8	67·5	43·25	28·5

The room in which the compressor is situated is 500 m. (1,640 ft.) above sea level. The excellent efficiencies obtained were considerably above guarantee. The power consumption of the compressor at no load is 56·65 kw., or 11 per cent. of the power consumption at full load. The isothermal efficiency at full load is 63·1 per cent. at three-quarter load, 62·5 per cent., at half-load, 58·7 per cent.; and at one-quarter load; 54·4 per cent.

Tractor Ploughing Trials in France.—The Fiat Company state that 50 manufacturers took part in the French autumn tractor ploughing trials, which were held this year on the eastern suburbs of Paris at the same time as the motor show. The machines were of French, British, Italian and American construction. One of the features of the trials was the use by the Fiat tractor of French national fuel in place of petrol or paraffin. This fuel consists of 50 per cent. benzole and 50 per cent. alcohol, and its use is being recommended by the Government in order to encourage agriculture and to make the French industry independent of foreign fuels. Better results were obtained with this fuel than with paraffin as usually employed on the Fiat tractors, the machines hauling six-furrow ploughs and working to a depth of nearly 8 in., notwithstanding the very hard ground, which had not been cultivated for seven years. Owing to a temporary shortage of benzole the percentage of alcohol had to be increased on one or two days to as high as 90; this, however, did not affect the working of the engine, nor was any difficulty experienced in starting up from cold. The only mechanical change made in the engine was a slight increase in compression, and the adjustment of the carburettor to get the best results with this fuel.

New Ventilating Plant for the Severn Tunnel.—Messrs. Walker Brothers (Wigan), Limited, Pagefield Iron Works, Wigan, have just been awarded by the Great Western Railway Company, the contract for the new ventilating plant for the Severn Tunnel. This firm constructed the original plant required during the driving of the tunnel, and, subsequently, the permanent plant which was installed when the work was completed and the tunnel opened for traffic thirty-four years ago, this latter having been in continuous operation during the whole of the period. The traffic having increased enormously the company's chief engineer considers it advisable to instal a plant of still greater power, and the new one will, we understand, have a capacity of 800,000 cub. ft. of air per minute. The fan will be of the Walker "Indestructible" type, the engine being of the single tandem compound condensing class. The engine, which will also be constructed at Messrs. Walker Brothers' works, will have many interesting features, the valve gear being similar in type to that upon eight other engines now in course of manufacture, a very high efficiency and steam economy being claimed for it. The valves will be placed in the cylinder heads, facility thus being given for jacketting the steam valves with live steam, the clearance also being reduced to a minimum. The new boilers which form part of the contract will be of the Lancashire type, with a steam pressure of 150 lb. per square inch, and will be fitted with superheaters and economisers. It is estimated that when this plant is in operation the air in the tunnel can be entirely changed about every 15 minutes.

GERMAN CAPITAL AND LABOUR.

In our issues of May 21 and 28, 1920, on pages 703 and 734, we published a translation of an address to the employees of the Allgemeine Electricitäts Gesellschaft by Mr. Felix Deutsch, chairman of the board of directors of that company. In that address some interesting statistics were given regarding the profits of a number of companies in order to show how much the workers would obtain if the whole of the profits were distributed among them without allowing anything for the use of the capital invested. Mr. Deutsch has recently published further statistics of a similar nature based upon information supplied to him by 152 of the leading factories in Germany, and as such statistics may do good in countering the labour propaganda for the socialisation of British industries, we give below a translation of Mr. Deutsch's latest communication, which is as follows :—

About two years ago I addressed myself to 66 limited companies engaged in widely different branches of industry in all parts of Germany, with a view to obtaining data from which I could compute figures for establishing the relation of the remuneration of labour to that of capital. The requisite data were readily put at my disposal, and this enabled me to put before the Berlin Chamber of Commerce, in April, 1919, a report, of which some 150,000 copies were distributed at the request of industrialists, politicians, newspapers of all parties, and others. Since that time a considerable change for the worse has taken place in our economic situation. Salaries and wages have increased at a rate which could not be foreseen, and the burden of national, municipal and social taxation imposed has become heavier than ever. These circumstances, together with the new heavy charges imposed upon Germany by the Allies, have induced me to ascertain once more the earnings of labour as compared with those of capital.

In my former report I arrived at the result that, in the average of ten years before the war, capital participated to the extent of 13 per cent. in the amounts that that were spent for wages, salaries and taxes, i.e., out of every mark expended, the labourers and employees received 76·7 pfg., the State and municipalities 11·7 pfg. and the shareholders 11·6 pfg. The demand for nationalisation has not ceased during the two years that have elapsed, although the general economic situation has grown worse, and though it seems hardly comprehensible that in such a time as this anybody can seriously consider the idea of nationalising industry. A Commission instituted for studying the question has for months made the most thorough investigations without arriving at any result. In spite of this the clamour for the transfer of vital industrial concerns like mining, electric lighting and power enterprises, &c., to public holding is still going on. This is the case although past experience, in the transfer of private enterprises to municipal or State administration, ought to have served as a warning against further progress along this dangerous path. The fate of the Grosse Berliner Strassenbahn, once a flourishing enterprise in the hands of an ably-managed private company, and now on the verge of ruin, is a typical example of the effects of "socialising"; and it is not the only case.

I have set myself the task of following the developments of these conditions since the end of the war, and I have been able, thanks to the assistance of numerous firms, considerably to extend the scope of my investigations. The facts given are based upon the figures for the year 1919–20, or 1920, as the case may be.

Table I, opposite, gives the number of workers employed by each firm, the total amount paid in wages and salaries, the sums expended on taxes and other public charges, the dividends paid per cent., the amount of dividend actually paid, the percentage of the participation of capital in proportion to the wages, salaries and taxes paid, a comparison of the current figures with those for the companies previously investigated, and the average dividends paid by each company during the ten years immediately preceding the war.

Table II, page 677, shows how, even in the case of firms paying considerably increased dividends in comparison with those formerly paid, the proportional participation of capital has greatly diminished. This fact is particularly noteworthy since it would naturally appear that the participation of capital could be higher in the case of increased dividends; the contrary is actually the case.

It will be seen later that in 153 firms a total nominal capital of approximately 10 billion marks is invested. This is made up of shares to the amount of approximately 5·600 billion marks and reserves and loans to the extent of 3·560 billion marks. The value of these shares at the bourse is at present nearly 24 billion marks. The firms employ nearly 1,350,000 workmen and employees, and wages and salaries to the amount of 16 billion marks, and taxes, &c., to the amount of 2·2 billion marks, have been paid. Dividends were paid to the amount of 650 million marks, which is 11·6 per cent. on the nominal capital and 2·7 per cent. on the market value. An attempt to obtain an approximate average percentage of dividends paid would result in the following figures: Total for 153 firms for the past year equals 2,419 per cent., or 15·8 per cent. as the average figure; and for the time before the war the total of 1,498 per cent. gives an average of 9·8 per cent. on the nominal capital. The participation of capital which, during the period covered by my first investigations had been 13 per cent. of the sums expended for wages, salaries and taxes, has therefore fallen to 3·2 per cent., so that out of every mark expended workmen and employees received before the war 76·7 pfg. and 84·9 pfg. in the later period, while the State received 11·7 pfg. in both periods and capital received 11·6 pfg. before the war and 3·2 pfg. in the later period.

These figures show that labour and staff during this period of monetary depreciation have managed considerably to increase their participation in the results of industry, that the State has not yet enforced its new taxes, and that capital has been compelled to be satisfied with a very much lower compensation for its efforts and risks. If one considers only the income of workmen and employees in proportion to the remuneration of capital it appears that before the war workmen and employees received 87 per cent. and capital 13 per cent., while the corresponding figures for the later period are 96 per cent. and 4 per cent. respectively.

Although these results may appear to be extraordinarily unfavourable to capital they are perhaps even better than the situation of industry would warrant. It is to be feared that many firms have deviated from the path of pre-war wisdom, and have distributed higher dividends without regard to depreciation, &c., so as to offer their shareholders an equivalent for the depreciation of the value of money. I propose to deal with this point later.

The above figures are confirmed by the statistics of the "Verein für die bergbaulichen Interessen," of Essen. According to these statistics, last year's figures would be as follows :—

Year.	Number of Workmen.	Total Wages.	Taxes and Other Public Charges.	Output.	Proportion of Output to Wages and Taxes.
		millions of marks.	millions of marks.		per cent.
1917	324,150	880	79·5	142	14·7
1918	322,880	1,081	100·2	128	10·8
1919	369,270	1,992	169·6	79·4	3·7

There are, however, three other features which have not yet been considered by me, and whose effects in the future will be of the greatest importance. These are :—

1. The subsidy paid by the State for grain.
2. The abolition of compulsory rents.
3. The considerably increased depreciation.

Grain.—It has been proved that the extra allowance paid by the Government has amounted to 200 marks per head, and if one averages the family of the above-mentioned 1,350,000 workmen and employees at four persons, this would result in a payment of more than one billion marks.

Compulsory Rents.—To-day's costs for construction are about 15 times what they were in peace time, and it may be assumed that the rent paid by the workman to-day amounts to 50 marks per month, and that of members of the staff to 100 marks per month. Using this assumption as a basis for calculating future rents, and if it be taken for granted that the increase of rents will be only six times that of to-day's figures (instead of 15 times, as the construction costs would warrant) it appears that the annual rent paid by a workman would be 3,600 marks and that paid by members of the staff 7,200 marks. For the above-mentioned numbers of workmen and staff this would mean a total increase of nearly 3½ billion marks.

Depreciation.—In this connection it is necessary to have a clear conception of the situation as it has developed for industry in the whole world. The prices of all materials, &c., have risen 2 to 2½ times in all foreign countries, and in Germany they have, as a consequence of the breakdown in our inflated currency soared up to the extent of 20 times their pre-war costs, and in many cases very much more than this. Owing to the fact that the capital of our industrial concerns is insufficient, very considerable increases of capital are essential to keep up production.

Until recently we have been able to allow for the usual depreciation of sums invested in machines, apparatus, tools, &c., because this normal depreciation was calculated in accordance with the life of the plant, and we were able, therefore, to accumulate the funds necessary for renewals.

With machines and apparatus costing to-day 16 to 18 times their cost before the war, these conditions have materially changed. We are not able to work with the former depreciation allowances, as this would mean nothing more than the consumption of the invested capital and the undermining of the very foundations of the enterprise. Instead, to acquire the necessary sums for renewals, which are of vital importance for keeping our industry efficient and able to compete, we are forced to put aside large sums for the renewal of obsolete plant.

The following example will help to explain this: In former times we in the A.E.G. used largely to employ certain types of machine tools for the operation of each of which one man was necessary. American machines were then offered to the company which could be operated three at a time by one man. As this meant very extensive savings we did not hesitate to expend the large sums necessary to procure them. Not very long afterwards America placed upon the market new machines of which nine could be operated by one man. It is quite obvious that only an enterprise with a very large output is able to utilise fully machines of this kind, and to bear the heavy expenditure necessary for their introduction. The manufacturies of the Allgemeine Elektricitäts Gesellschaft were able to do this because they had a customer available, viz., the sales organisation of the company all over the world, with its nearly 400 branches, and they could therefore afford the risk of replacing the machines bought only a few years before by more efficient and very expensive ones. The results obtained showed that our action was justified, and we were soon able to increase our output by more than five times. We had, however, only been able to do this because

TABLE I.

Number of Firm.	Total Number of Staff and Employees.	Total Wages and Salaries in Millions of Marks.	Taxes and Social Charges in Millions of Marks.	Dividends, per Cent.	Amount of Dividends Paid in Millions of Marks.	Percentage Participation of Capital to Wages, Taxes and Social Charges. 1919–20.	Percentage Participation of Capital to Wages, Taxes and Social Charges. Previous Period.	Average Dividends for Last Ten Years Prior to War.
1	4,900	60	9	20	3	4·4	16·4	21
2	59,000	602	71	14	28	4·2	19·8	12·8
3	6,800	62	12	10	3·6	5	21·6	23·4
4	12,000	117	19	15	12	8·7	14·1	8·8
5	4,800	55	3	12	2·1	4·6	10·7	9·1
6	12,800	112	18	28	6·1	4·7	14·2	13·4
7	10,000	145	23	12	1·2	0·7	3·1	5·4
8	22,800	200	14	15	10·5	4·8	15·6	16·1
9	4,000	41	4	30	3	6·6	19·5	12
10	7,200	87	18	6	4	3·5	9·2	7·4
11	9,900	111	8	12	3·5	6·4	12·2	6·3
12	9,400	141	27	6	1·6	1	17·5	11
13	600	5	2	25	1	15	14	11·5
14	11,400	113·5	32·5	5	3·4	2·3	9·2	16·6
15	6,800	87	7	20	6	6·4	8·4	8·8
16	1,100	11	2	12	2	16	50	8·6
17	46,700	422	88	12	15·6	3	9	8
18	2,900	35	10·5	30	9	20	18·3	28·3
19	4,600	55	3	10	2·3	3·9	18·2	7·2
20	10,000	117	21	10	1·5	1	13·6	16·9
21	4,000	62	9·5	40	9	12·5	34·1	10·3
22	6,800	94·5	28·5	20	18	14·6	24·6	9·7
23	51,800	569	109	12	11·7	1·7	15·9	9·6
24	34,600	515	73	20	16	2·7	9·3	18·5
25	—	—	—	—	—	—	25·7	12·7
26	6,700	64	8·5	30	4·8	6·6	16	23·4
27	34,700	361	26	12	9·2	2·4	12	9·3
28	7,000	45·5	0·5	18	5·4	10	13·4	8·2
29	12,000	135·5	9·5	5	4	3·4	30·7	6·7
30	4,700	42	3·5	6	1·6	3·7	14·5	7·8
31	17,400	160	39	24	7·6	3·8	15·7	20·8
32	5,200	65	20	16	2	2·7	3·1	6·5
33	29,000	266	3·5	15	9	3	6	8
34	3,000	27	16	30	3·7	12·3	20·6	8·7
35	93,400	695	146	7	—	0	8·5	10
36	19,400	1254	27	12	6·2	2·4	20·8	12·6
37	9,500	120	8	20	4·4	3·5	12·2	12·1
38	10,800	115	19	24	7·8	5·8	16·9	20·7
39	17,900	137	15	10	5·4	3·5	11	16·3
40	22,300	197	85	20	17·2	6	25·4	12·7
41	1,400	12	1	12	1·4	11	14	7·5
42	3,400	31	8	12	3	1·6	3	10·8
43	21,700	153	20	25	16	9	13·3	6·9
44	16,400	178	58	20	10	4·3	9·1	6·4
45	11,100	140	20	31	18·6	11·6	18·6	12·6
46	800	11	4	120	4·5	30	15·9	7·3
47	42,500	386	32	20	21·2	5	19·5	15·7
48	5,500	47	4	20	3·6	7	20·7	9·9
49	2,700	33	3	17	2	5·7	16·5	11
50	3,100	20	1	10	0·6	3	5·5	5·5
51	3,300	34	3	20	2·4	6·6	11·7	14·3
52	1,300	14	3	40	4	2·2	47	16·2
53	14,600	187	10	—	—	—	4	4·7
54	—	—	—	—	—	—	30·2	8·5
55	23,300	362	48	20	13	3·2	15·6	9·2
56	1,700	21	1	8	0·8	3·7	13·1	8
57	1,000	5	2	10	1	14	12	11·6
58	5,700	63	8	18	3·2	4·5	14·1	18·2
59	74,000	740	52	9	18·6	2·3	10·8	9·7
60	4,500	40	12	16	6·4	12·3	10·3	14·1
61	13,400	151	45	15	3·7	2·2	26·2	14·1
62	3,400	38	28	50	12·5	19	21·8	21·8
63	4,000	40	3	25	1·5	3·4	7·5	9·2
64	40,000	663	75	—	—	0	0·6	4·3
65	14,900	165	17	12	1·8	1	4·3	7·4
66	8,600	95	9	10	1·5	1	2·5	6·7
67	9,300	135	59	5	2·1	1	—	—
68	11,200	149	25	15	3·3	1·9	—	20·3
69	3,000	25	3	20	2·3	8·2	—	10
70	1,900	23	2·3	20	5	19·7	—	8
71	6,100	66	6·4	12	2	2·7	—	9·4
72	4,200	42	5	20	3·4	7·2	—	12·8
73	1,900	17	2	30	2·7	14	—	8·3
74	6,400	49	5	16	4·8	9·0	—	17·5
75	5,100	76	18·5	14	4·2	4·4	—	13·8
76	5,700	59	13·5	16	3	4	—	10·8
77	7,300	60	4	10	2	3	—	9
78	800	7	1	12	0·6	0·8	—	10
79	1,000	6	1	15	0·3	5	—	14
80	1,200	16·6	1·3	30	3	16	—	15·4
81	1,400	21	2	20	1	4·3	—	9·9
82	6,500	53	2	18	9	16	—	13·5
83	7,300	109	10	15	6·7	5·6	—	35·9
84	8,400	156	18	25	5	2·8	—	19·5
85	500	4	2	10	0·5	8·3	—	—
86	10,700	181	23	8	1·6	7·8	—	—
87	900	9	5	10	1·4	10	—	—
88	3,500	48	11	28	2·7	4·8	—	8
89	6,200	106	4	22	2·2	2	—	13·6
90	4,300	75	7	11	4·3	5·2	—	20
91	6,500	85	10	17	3	3·1	—	14·5
92	3,800	45	7	—	—	0	—	80
93	1,500	13	1	14	1·2	9	—	—
94	600	6·5	2	15	0·6	7	—	15·4
95	1,300	14	8	25	1·5	7	—	16
96	4,500	39	4	18	1·7	4	—	15
97	2,200	38	5	9	0·4	1	—	25
98	15,200	234	68	12	9	3	—	11·9
99	5,100	83	6	20	1·7	2	—	10·2
100	1,700	15	4	20	5·1	28	—	14·9
101	800	5	2	15	0·7	12·5	—	14·1
102	1,200	12	1	12	0·8	6	—	15
103	1,400	12	3	10	0·8	5·5	—	4·9
104	10,800	127	25	8	1·5	0·9	—	23·5
105	2,600	28	3	12	2·1	7	—	9·9
106	1,400	17	2	20	1·3	6·6	—	2·8
107	2,300	31	8	20	2·6	1·4	—	8·4
108	2,000	19	3	5	0·3	15	—	10·6
109	800	7	2	35	1·2	7	—	—
110	2,300	26	7	15	3·5	10	—	28
111	1,450	20	4	25	1·9	8·4	—	8·5
112	23,100	398	29	12	7·6	1·8	—	11·4
113	1,300	14	3	4	0·8	4·7	—	6·6
114	6,000	72	14	15	7·5	8·7	—	7·4
115	8,600	106	16	22	7·5	6	—	11·7

TABLE I—*continued.*

Number of Firm.	Total Number of Staff and Employees.	Total Wages and Salaries in Millions of Marks.	Taxes and Social Charges in Millions of Marks.	Dividends, per Cent.	Amount of Dividends Paid in Millions of Marks.	Percentage Participation of Capital to Wages, Taxes and Social Charges. 1919–20.	Percentage Participation of Capital to Wages, Taxes and Social Charges. Previous Period.	Average Dividends for Last Ten Years Prior to War.
116	4,400	31	4	18	1·9	5·4	—	9·3
117	900	7	2	—	—	0	—	16
118	4,300	64	16	20	2·2	2·7	—	14·1
119	2,100	19	3	15	1·2	5·4	—	6·5
120	800	7	2	30	1·2	13	—	8
121	4,000	47	10	15	2·2	3·8	—	11
122	800	9	3	20	1·5	13	—	10·6
123	1,500	21	3	12	2·1	8·7	—	8·7
124	1,200	15	6	30	2·4	12	—	10
125	2,100	20	14	25	2·5	7·4	—	25·0
126	3,500	36	4	24	3·6	9	—	23·7
127	2,100	21	4	12	0·6	2·5	—	7
128	1,700	15	2	12	0·9	5·7	—	14·1
129	2,100	34	3·3	20	1·6	4·3	—	30
130	21,500	240	22	16	6·9	2·6	—	13
131	4,500	61	14	10	1	1·4	—	6·4
132	2,400	22	4	15	1·9	7·3	—	7·7
133	4,800	66	5·3	6·6	1·2	1·7	—	—
134	5,700	83	11	12	1·68	1·8	—	10·2
135	2,200	17	2	12	0·96	5·2	—	6
136	1,900	19	2	12	0·48	2·3	—	6
137	8,200	105	18	22	5·50	4·1	—	12·2
138	2,000	20	1	20	1·95	9·7	—	16·3
139	1,300	5	2	9	0·70	12	—	12
140	8,400	151	16	20	12·40	7·4	—	11·6
141	800	8	6	40	5·60	40	—	18
142	12,900	139	14	15	4·3	2·8	—	12
143	5,300	88	11	24	7·2	7·3	—	13
144	12,300	135	11	10	15·4	10	—	8
145	3,400	29	3	20	3	9·4	—	5·8
146	500	6	2	15	1·26	16·5	—	7
147	2,100	26	2	7	0·28	1	—	16
148	5,500	59	2	18	1·80	3	—	10
149	800	9	2	30	1	10	—	9
150	2,300	17	4	10	1·6	7·6	—	6
151	2,500	21	3	10	0·80	3·3	—	14
152	5,900	49	23	30	8·30	11·4	—	1841·4
Ttls	1,332,550	15,812	2222·1	2586·6	650·1	3·4	13	

TABLE II.

No. of Firm.	Dividends in Per Cent. 1908–17.	Dividends in Per Cent. 1919–20 or 1920.	Proportion of Capital Participation. 1908–17.	Proportion of Capital Participation. 1919–20 or 1920.
2	12·8	14	19·8	4·2
4	8·8	15	14·1	8·7
5	9·1	12	10·7	3·6
6	13·4	28	14·2	4·7
7	5·4	12	3·1	0·7
9	12	30	19·5	6·6
11	6·3	12	12·2	6·4
15	8·8	20	8·4	6·4
16	8·6	12	50	16
17	8	12	9	3
18	7·2	10	18·2	3·9
19	10·3	40	34·1	12·5
21	9·7	20	24·6	14·6
22	9·6	12	15·9	1·7
23	18·5	20	9·3	2·7
24	23·4	30	16	6·6
26	9·3	12	12	2·4
27	8·2	18	13·4	3·8
28	20·8	24	15·7	10
31	6·5	20	3·1	2·7
32	8	16	6	2·7
33	8·7	15	20·6	12·3
34	20·7	24	16·9	5·8
38	12·7	20	25·4	6
40	7·5	12	14	11
41	6·9	25	13·3	9
43	6·4	20	9·1	4·3
44	12·6	31	18·6	11·6
45	15·7	20	19·5	5
47	9·9	20	20·7	7
48	11	17	16·5	5·7
49	5·5	10	5·5	3
50	14·3	20	11·7	6·6
51	16·2	40	47	11
52	9·2	20	15·6	6·6
53	14·1	15	20	3
55	21·8	50	20·6	12·3
56	7·4	12	16·9	5·8
57	6·7	10	4·3	1
58			2·5	1

the full depreciation for the former machines had been allowed for. If this had not been the case we should not have been able to pay for the amortisation of the new machines, and more alert and prudent contractors would have secured the business. This example holds good for the whole German industry to-day. Naturally, many concerns, in addition to the usual depreciation allowances, have accumulated large reserves by prudent valuation of investments and stores. But the question arises as to whether these are sufficient, and whether they provide the necessary security which to-day, more than ever before is essential. This question is growing to be more and more threatening.

Before the war German industry led the way in engineering work. It had taken a foremost position in connection with all investigations of new problems and in the design of new types. The prudent dividend policy of a decennium had given Germany the means for doing this without injury to her current business. Now the situation has undergone a fearful change. Our pitiful rate of exchange makes it nearly impossible for us to compete with high currency countries in this field, and it seems to be very improbable that we can go on expending the enormous sums for progressive work which are necessary to-day if production is to attain the top notch of efficiency and if new markets are to be found. German industry will therefore not be able to maintain its former position and reputation in the markets of the world, if it is prevented from expending considerable sums for patents, new designs and investigations without weakening its present position. When this does happen, it will also not be able to consider its workmen and staff, and in the case of depression will have to go to the extreme measure of discharging great numbers of them in order to avoid the collapse of the whole concern.

It must also be taken into consideration that in consequence of the depreciation in the value of money it has been necessary to tie up enormous sums in stocks, and that great losses are being sustained because of the continuous decline in the prices of materials on the world's markets. Moreover, reserves are necessary to protect the market from disturbances, and the industry requiring money must endeavour to retain the confidence of the capitalist. Heavy fluctuations of dividends would scare away capital and would render it more difficult, if not entirely impossible, to satisfy new financial requirements. All these conditions must be covered by reserves, and every solvent firm must make it its business to fulfill them.

The far-sighted policy which has been followed by German industry up till now in the matter of depreciation and reserves, as has already been indicated, can hardly be kept up with to-day's costs for renewals, &c. With the total dividends amounting to not more than 650 million marks, the question arises as to how to meet the enormous expenditure which will be further increased when the financial effects of the first two indicated above, viz., the increase in the price of bread and the compulsory rents, become noticeable. Both will have to be partly borne by capital in the form of higher wages and salaries paid. The consequences are obvious. The participation of capital which has already been reduced to a most dangerous degree will continue to decrease, and consequently capital will withdraw its investments from industry. Afterwards, with the gradual improvement of our finances and with the recovery of our currency, *i.e.*, when our bank-note presses stop flooding the market, money will grow scarce, rate of interest will increase, and even our most firmly-established industries will find it almost impossible to raise money.

It is often said that foreign countries will place large sums at our disposal, but with such conditions, how can we expect it of them? Even in the United States money is tight, and industry and commerce find it difficult to raise the necessary funds, because money is largely invested in Federal and Municipal bonds, which are exempt from taxation, while all other kinds of investments have to pay very high taxes. If the earning power of capital steadily decreases at the rate indicated above, foreign capital, which, in the United States for instance, receives a fixed rate of interest of 7 per cent. to 8 per cent. for perfectly safe investments, will find no inducement for investment.

A comparison of to-day's sales, profits and dividends with those of pre-war times is impossible because of the entirely different conditions. Although the figures themselves appear to be satisfactory they actually represent sales of little more than 40 per cent. of those of peace times. Moreover, in the case of the large dividends distributed during the last two years, of which one hears so much, they are only paper mark dividends. The 15·8 per cent. dividends which are paid to-day amount to about 1 per cent. of the nominal capital invested in gold marks. In my former statement I showed that the capital invested in the concerns under consideration had, in peace time, drawn 5 per cent. interest, and no sensible man will think this an excessive rate, after taking into account the natural risks in connection with market fluctuations and competition, and when he remembers the fact that State bonds also bring in 5 per cent. interest. At the present time, even a 10 per cent. paper mark rate of interest on invested capital would mean a very much decreased earning power of the capital, when one considers the depreciation of money value which has led to an increase of wages amounting to 8 or 10 times the peace-time rates. But the above has shown that shareholders to-day receive only about 2·6 per cent. interest; and this is in paper marks.

If one goes on to consider that income tax which varies between 10 per cent. and 60 per cent., swallows up at least 45 per cent. of all incomes of more than 50,000 marks (4,000 gold marks), it would appear that there is some danger that we shall eventually arrive at the same conditions as now exist in Russia, where every one finds it worth while only to work just enough to ensure a bare subsistence. It cannot be too strongly emphasised that this would mean the destruction of civilisation and of all that has been achieved by the work of centuries.

In conclusion I wish to say a word about the often-suggested plan of allowing the workmen and staff a share of the profits. As has been shown above, the dividends of the year ended, which can well be termed the year of catastrophic booms, amounted to 650 million marks. If one only allows a dividend of 5 per cent. for the nominal capital of 5·6 billions, *i.e.*, 280 millions, there would be 370 millions left which could be shared between the employees. This would mean that each would receive less than 2·3 per cent. of his average income of 11,630 marks, and this proportion would

naturally diminish as wages increased and dividends diminished.

An exactly similar result is shown in a detailed report on this question which the British Ministry of Labour laid before Parliament a year ago. In this report it is shown that since 1829, a total of 380 concerns in England have adopted the profit-sharing system. Although most widely varying systems have been employed, the results seem to have been unsatisfactory, since 200 of the 380 concerns abandoned the scheme after a very short time. In constructional work only three of the 14 plants which introduced the system are still employing it; in the printing and book-binding trade 12 of the original 38 firms are still working with it; and of the 10 firms which introduced the system in the timber trade only one firm, employing 60 workmen, still retains it. There is, however, one branch of industry in which the system seems to have been permanently established, viz., the gas industry. Of the 40 firms which originally introduced it, 36 are still employing it, but the report shows that the reasons for this are to be found in the large and regular demand for the products of the industry and in the distribution of the profits in accordance with the sliding-scale wage system.

A closer investigation of the figures gives the following results for 1918 :—

Trade.	Number of Enterprises Applying Profit-Sharing System.	Number of Employees Participating.	Total Profits.	Share of Profit per Head.
			£	£ s. d.
Chemical, oil, &c.	5	2,393	30,509	12 15 0
Food-stuffs ..	10	3,622	43,396	11 19 7
Gas works ..	31	22,447	24,895	1 2 3
Machine shops, &c.	6	15,004	34,415	2 5 10
Printing trade, &c.	10	3,870	29,461	7 12 3
Clothing trade, &c.	9	5,784	52,254	9 0 8
Commerce, &c...	15	6,959	67,817	9 14 11
Insurance, &c...	1	18,500	—	—
Other trades ..	18	3,254	16,891	5 3 10
Total ..	105	81,833	299,728	3 13 3

Thus 300,000*l.* were divided among 82,000 persons, so that each received 3*l.* 13*s.* = 73 gold marks, or about 2½ per cent. on his total income. This is an amount which, naturally, does not seem very interesting to us, and no one will regard it as an incentive for increasing output.

That is the reason why I have always been opposed to the system. I regard it as the upshot of embarrassment and of inability to find a better solution; moreover, it is, in my opinion, a false pretence. The small sums that are distributed will soon create an atmosphere of disappointment, and we would have disturbed our whole economic life with the only result that the discontent would have increased and our system of production become the object of new attacks. What the socialist papers have been proclaiming with so much enthusiasm, viz., that the workmen participating in the profits would work harder and take more interest in the business than a colleague who is only paid his wages, would be the least likely result of the introduction of the system, although this might be possible in the case of small concerns where there is some link connecting the employer and employees. In the case of large concerns, however, in which every one, the lowest and the highest alike, is but a small link in a great chain, this is utterly impossible.

The White Star Liner "Homeric."—We are informed that the new White Star Line twin-screw, 35,000-ton steamer Homeric will enter the company's Southampton, Cherbourg and New York mail and passenger service in the spring. In this service she will be associated with the Olympic, 46,439 tons, and later with the Majestic, 56,000 tons. The Homeric has two funnels and two pole masts. She is 775 ft. in length, and her breadth is 83 ft.; her triple expansion engines will give her an average sea speed of 19 knots. The combined passenger and crew capacity is 3,500. She will have accommodation for between 400 and 500 first-class, about 500 second-class and 1,800 third-class passengers.

Helmholtz-Gesellschaft for Physico-Technical Research.—A new Helmholtz-Gesellschaft zur Förderung der Physikalisch-Technischen Forschung was inaugurated last month in Jena, the date nearly coinciding with the one hundredth anniversary of the birthday of Helmholtz. Invitations had been sent out to representatives of the physical institutes of German Universities and to representatives of the various laboratories, comprising electric and engineering laboratories, of the Technical High Schools. The society is intended to bring the scientist and practical men together and will not interfere with the work of existing institutions. The lectures delivered at the inaugural meeting covered a wide scope, too wide almost. Professor Lenard lectured on Experimental Atomistic; Professor Schumann on High Tension Electric Discharge and Ionisation; Dr. Kessler, of Messrs. Zeiss, on Optical Technics; Professor Willy Wien, vice-president, also discoursed on Helmholtz. Dr. Ing. Vögler is the president, and Dr. Ing. Petersen, manager of the Verein deutscher Eisenhüttenleute, has accepted the post of secretary and manager to the new institute.

AN INVESTIGATION OF HOT DRAWING ON THE MANDRIL.*

By Eugene Schneider (Past-President).

Introduction.—The operation of hot drawing on the mandril is relatively simple, but in spite of that the actual conditions under which the work is carried out are rather little known.

To study the elements of drawing the practical man bases his knowledge on preceding work which has given good results, and in this way surprises often occur in the tests. Moreover, the conditions of efficiency are bad.

The very large variety of blanks of all dimensions that we have been called upon to manufacture permits us to make numerous observations. The study that we have drawn up is made especially for the needs of the shop; the theoretical part has been reduced as much as possible, and the conclusions should permit of a very rapid and certain determination at sight on all the elements of a drawing.

The trial tests can be done without fear of any incidents, and the operation giving the best efficiency for a specific product with hydraulic machines of specified duty can be obtained.

Under these conditions the method of working will no longer be empirical.

PART I.

Generalities.

I. *Object of Drawing.*—The drawing on the mandril has for its object the lengthening of a hollowed blank obtained by punching or casting and keeping it, by means of a mandril, the required internal section and dimensions.

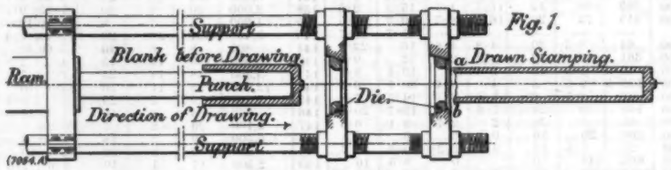


Fig. 1.

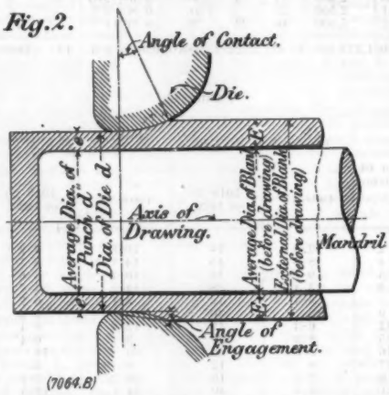


Fig. 2.

II. *Description of Drawing.*—The operation of drawing is carried out with the aid of different machines; hydraulic drawing press, draw benches, mechanical or electrical draw presses.

Generally, and especially in the cases that we have studied, the hydraulic press is the machine used.

The mandril or punch is fixed to the crosshead of the press, as indicated in Fig. 1.

On this mandril the blank to be pressed is introduced.

By its forward movement the punch entrains the rough blank and makes it pass in one or several dies placed on the same centre line as the punch, and their internal diameters are such that they can create the required elongation of the blank as it passes each one.

The blank thus pressed perfectly fits the profile of the punch.

To disengage it, at the end of the stroke between the free section *a b* of the blank and the die-plate carrier, an extractor which caps the punch is interposed, which on the return stroke of the press rests against the section *a b*, which causes disengagement.

III. *Definitions and Formulæ.*—Fig. 2 represents a blank in the course of drawing. For the study which follows we will adopt the following notation and definitions :—

D.—Average external diameter of blank before drawing.

d'.—Average internal diameter of blank before drawing.

E.—$\frac{D - d'}{2}$. Average thickness of blank before drawing.

d.—Diameter of die or diameter of blank after drawing.

d''.—Average diameter of punch.

e.—$\frac{d - d''}{2}$. Average thickness of sides of blank after drawing.

θ.—*Angle of Contact.* This angle is determined by the two connecting radii of the die, which indicate the limits of the zone of the blank in contact with the die during drawing.

$\frac{\theta}{2}$.—*Angle of Attack.* This angle is that made by the chord of the arc of contact with the press axis.

S.—*Remaining Section* $= \frac{\pi}{4}(d^2 - d''^2)$. This section is that of the blank after its passage in the die.

s.—*Displaced Section* $= \frac{\pi}{4}\left[(D^2 - d'^2) - (d^2 - d''^2)\right]$.

This section is the difference of the sections of metal of blank before and after drawing.

A per cent.—Elongation per cent. $= \frac{s}{S} \times 100$.

IV. *Generalities on the Forms of Roughed Blanks and Tools Used.*—(*a*) *Roughed Blanks.*—When referring to roughed blanks required for reservoirs, tubes, &c., the interior is cylindrical before drawing, and the internal diameter is slightly larger than the diameter of the punch in order to allow the entry of the latter to the bottom of the blank.

For the manufacture of shells the interior form of the roughed blank is different; the lower part is always conical, but the maximum internal diameter remains larger than that of the punch. We understand by internal diameter of the blank before drawing, the diameter corresponding to the largest diameter of the punch.

The external form of the blanks is variable according as to whether they have not been drawn, or submitted partially to this operation. We will distinguish therefore the two cases.

1. The blank is punched but not drawn.

The external form is the same as that of the die of punching, it is therefore conical. We will assume that the average external diameter and the average thickness before drawing are measured at half height of the upper cone of the die.

2. The blank has already been partially drawn. The external form is cylindrical.

(*b*) *Punches.*—The mandrils or punches are all more or less conical according to the product to be obtained.

In the case of tubes or of reservoirs where the thickness of the walls must be as regular as possible, the coning of the punch is small; in this case we will take as average diameter, the average diameter of the part covered over by the drawn blank.

For the manufacture of shells the punch generally consists of several cones, as indicated in sketch on the opposite page (Fig. 3).

In this case we will take, as average diameter of the punch, the average diameter of the largest part covered over by the drawn blank.

(*c*) *Dies.*—The dies we utilise are of two types, of which the sections are indicated in Figs. 4 and 5.

Type 1.—The section of the die consists of a rounded portion of radius R, which connects to a cylindrical portion *a b* of variable length, but always rather small.

To simplify the study we assume that the rough blank adheres to the punch in the region in contact with the die.

The angle of contact θ therefore corresponds to the diminution of thickness of side E *e*.

Type 2.—The section of the die consists of a rounded portion of radius R, connecting on one side to the cylindrical part *a b* and on the other to a conical part *c d*. In the case where the contact of the blank will be made on the conical part *c d* (at A, for example), we will have as arc of contact the portion A *a*, and in order to be able to compare with dies with ordinary connection, we will assume that the portion A *a* is equivalent to the arc of a circle whose centre is situated on the line *a x*, this arc passing by *a* and A.

The angle of contact will be that indicated in Fig. 5.

PART II.

Examination of the Working Conditions.

I. *The Different Forces in Operation during Drawing.*—Suppose a blank in course of drawing is as represented in Fig. 6. We will assume that at the moment the diameter of the punch and of the blank are the average diameters defined above.

To simplify the study we will suppose that the internal diameter d' of the blank before drawing is the same as the average diameter of the punch.

By the intermediation of the punch the blank is submitted to a tensile force P, which acts on the section of the metal situated behind the die.

The section of the metal of the blank after its passage in the die, that we have termed the remaining section S, is equal to $\frac{\pi}{4}(d^2 - d''^2)$.

If ϕ is the strain per square millimetre carried by the remaining section, we have :

$$\phi \times S = P \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The tensile force P is balanced by the resistance opposed

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* Abstract of paper read at the Paris meeting of the Iron and Steel Institute, Tuesday, September 6, 1921.

on the die by the section of metal in contact with it, that is to say, by the section of metal displaced s, which is equal to $\frac{\pi}{4}(D^2 - d^2)$.

If we call R the resistance per square millimetre of the metal to displacement, the total resistance opposed by the section s will be $R \times s$.

We shall have therefore—

$$P = R \times s \quad . \quad . \quad . \quad . \quad . \quad (2)$$

From formulæ (1) and (2) we have :

$$\phi \times S = R \times s, \text{ from which } \frac{\phi}{R} = \frac{s}{S}.$$

The strain carried by the remaining section is equal to the resistance to displacement of the section displaced. In order that a blank can be drawn, it is therefore necessary that the strain ϕ per square millimetre of remaining section be less than the breaking strain.

The formulæ $\frac{\phi}{R} = \frac{s}{S}$ also shows that $\frac{\phi}{R}$ is equal to the ratio of the section displaced to the remaining section, or, in other words, to the elongation.

We will determine in what limits R and ϕ can be varied. These values once known allow us to determine all the elements for drawing.

II. *Measurement of the Power necessary at Drawing.*—

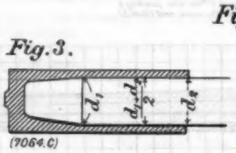


Fig. 3.

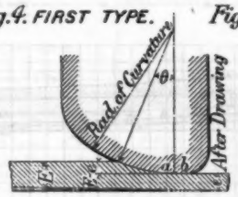


Fig. 4. FIRST TYPE.

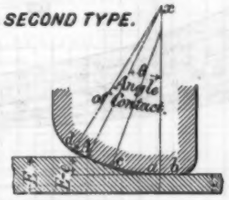


Fig. 5. SECOND TYPE.

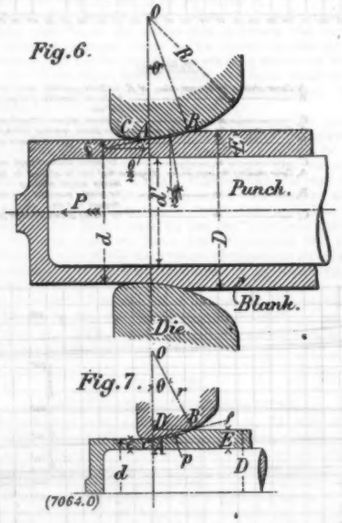


Fig. 6.

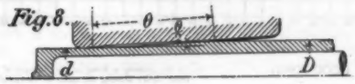


Fig. 8.

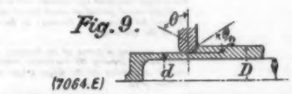


Fig. 9.

Fig. 7.

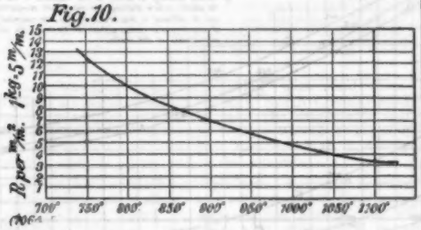


Fig. 10.

In order to be able to find the different values of R and ϕ, it is absolutely necessary to know exactly the power required in drawing.

Numerous readings have been made by the aid of an apparatus registering times and pressures in relation to the stroke. These have led to the knowledge of the points in question.

III. *Variations of the Resistance to Displacement* : R—In practice the connecting radius of the dies is sufficiently large and in the neighbourhood of 100 mm., and for very important passes the diminution of thickness of the sides is scarcely ever more than 15 mm. One can, without any appreciable error, replace in the calculation the arc of contact A B by the chord A B.

We have seen that if P is the force necessary for drawing, this force is balanced by the resistance to displacement of the section of metal to be displaced.

$$P = R \times s.$$

This resistance to displacement is due :—

1. To the reaction of the metal on the part A B of the die.

2. To the friction (rubbing) of the zone of contact with the die.

Let p be the unit pressure on the die and l the length of the chord A B.

The surface of the cone of contact (in replacing, as we have said, the arc A B by the chord A B) is :

$$s' = \frac{\pi (D + d)}{2} \times l,$$

or

$$l = \frac{D - d}{2 \sin \frac{\theta}{2}}$$

from which

$$s' = \frac{\pi (D^2 - d^2)}{4 \sin \frac{\theta}{2}}$$

The total reaction on the cone of contact of the die is therefore :

$$P_1 = p \times \frac{\pi (D^2 - d^2)}{4 \sin \frac{\theta}{2}}$$

and the projection of this reaction on the centre line is equal to :

$$P'_2 = p \times \frac{\pi (D^2 - d^2)}{4 \sin \frac{\theta}{2}} \times \sin \frac{\theta}{2} = p \times \frac{\pi}{4}(D^2 - d^2).$$

The friction on the cone of contact in designating f the co-efficient of friction is :

$$P f = p \times f \times \frac{\pi (D^2 - d^2)}{4 \sin \frac{\theta}{2}}$$

and the projection of this force on the centre line is :

$$P f = \frac{\pi (D^2 - d^2)}{4} \times \cot \frac{\theta}{2} \times p \times f.$$

In the cylindrical part A c of the die there is also friction, but it is only due to a pressure p', a function of the elasticity of the metal which has been drawn. Or in hot metal at the usual working temperatures this elasticity is practically zero, and on the other hand, the length of the cylindrical portion of the dies being generally small, we can neglect this friction in the equation of equilibrium.

(In cold-drawing this term would not be negligible, since the elasticity is higher when the pass is heavier, that is to say, when the drawn part has undergone more cold work.)

We have therefore the equation of equilibrium :

$$P = P' + p'f,$$

where

$$P = p\frac{\pi}{4}(D - d^2) + p f \cot \frac{\theta}{2} \times \frac{\pi}{4}(D^2 - d^2),$$

or

$$P = \frac{\pi}{4}(D^2 - d^2)\, p \left(1 + f \cot \frac{\theta}{2}\right).$$

We have seen that

$$\frac{\pi}{4}(D^2 - d^2) = s = \text{section drawn away.}$$

Therefore

$$P = s \times p \left(1 + f \cot \frac{\theta}{2}\right)$$

Where the resistance to displacement

$$R = p \left(1 + f \cot \frac{\theta}{2}\right) \quad . \quad . \quad . \quad . \quad (1)$$

1. *Variation of* R *according to Section of Die.*—We can allow that for the same temperature and dies in the same state p and f are constant. It is seen therefore from equation (1) :—

If we operate under the same conditions of temperature and with dies whose surfaces of contact are in the same state, the resistance to displacement increases as the angle of contact decreases.

In other words, for a given pass, the greater the angle of contact, or the smaller the connecting radius, the less becomes the power necessary for drawing.

If the angle of contact θ is very small (Fig. 8) the value of cot. $\frac{\theta}{2}$ is very great, consequently the friction increases, and, due to the normal reaction, the metal tends to wedge instead of to be displaced.

If, on the contrary, assuming always a same reduction of section, the angle of contact θ is very great (Fig. 9), cot. $\frac{\theta}{2}$ decreases and the friction becomes negligible. The power necessary then becomes in the neighbourhood of the minimum. The section of the metal to be displaced works at this moment under shear, and the effort of drawing can create tears on this section.

From this it appears that it is advantageous to employ dies of small connecting radius.

However, in order to avoid the tearing of the metal which would result from a very short cone, it is necessary to find a normal section, and it is experience which has enabled us to determine this.

The angle of attack $\frac{\theta}{2}$ which seems to be the limit of the opening of the cone, is about 15 deg. For a larger inclination there is the risk of the tearing of the metal to be displaced.

We have allowed for $\frac{\theta}{2}$ as maximum : 15 deg.*. Now cot. 15 deg. = 3·75 in round figures.

Consequently for this maximum angle

$$R = p\,(1 + 3{\cdot}75\, f).$$

Fig. 7 gives us

$$\text{Cot } \frac{\theta}{2} = \frac{BD}{AP}$$

or

$$B\,D = \sqrt{\left(2r - \frac{(D - d)}{2}\right)\frac{(D - d)}{2}}$$

and

$$A\,D = \frac{D - d}{2}$$

from which

$$\text{Cot } \frac{\theta}{2} = \sqrt{\frac{\left(2r - \frac{(D - d)}{2}\right)\frac{D - d}{2}}{\frac{(D - d)^2}{2}}} = \sqrt{\frac{2r - \frac{D - d}{2}}{\frac{D - d}{2}}}$$

If we make

$$\frac{\theta}{2} = 15 \text{ deg.} \quad \cot \frac{\theta}{2} = 3{\cdot}75$$

we have

$$3{\cdot}75^2 \times \frac{D - d}{2} = 2r - \frac{D - d}{2}$$

or in round figures

$$2r = 15 \times \frac{D - d}{2}$$

from which

$$r = 7{\cdot}5 \times \frac{D - d}{2}$$

Consequently—

For a diminution of thickness of sides $\frac{D - d}{2}$ the die which permits working under the best conditions is that where the connecting radius is equal to about 7½ times the diminution of the thickness of sides.

This condition of efficiency of the die does not always occur in practice, especially where different passes must frequently be made on very different blanks.

It can be imagined the stock of dies it would be necessary to have at hand for a given blank, the die being to convenient section.

Value of the Coefficient of Friction.—The value of the coefficient of friction is rather difficult to determine exactly, since it is a function of the state of the surfaces of the die and of the blank, as also of the temperature of drawing.

In cold-drawing, with polished dies and with blanks without wrinkles, Codran gives $f = 0{\cdot}15$. In rolling a coefficient of friction of 0·35 to 0·4 is allowed. The temperature of rolling being generally higher than that of drawing, we can allow without serious error $f = 0{\cdot}35$ for all hot-drawing.

This coefficient varies with the degree of wear of the die. One can observe that in normal operation by the following fact : If we draw with a very worn die presenting large erosions and where we can replace it by a new die of a little less diameter, we find a slight reduction of pressure at the press-head, namely a reduced power absorbed due to the fact that f is reduced.

Nevertheless as our tables have been made during normal operation, with dies practically in a similar state, we allow practically as a constant value of the coefficient of friction, $f = 0{\cdot}35$, in the ordinary limits of the temperatures of drawing.

If we take the best conditions of die section, that is to say, with

$$r = 7{\cdot}5\,\frac{D - d}{2} \text{ and } f = 0{\cdot}35$$

we have

$$R = p \left(1 + f \cot \frac{\theta}{2}\right)$$

where

$$\left(1 + f \cot \frac{\theta}{2}\right) = 2{\cdot}31$$

$$R = 2{\cdot}31\, p.$$

2. *Variations of* p.—The temperatures of drawing

* It should be noted that this angle of attack, which corresponds to an angle of contact $\theta = 30$ deg., puts us practically in the same conditions as for rolling where a maximum angle of contact of 28 deg. is allowed.

ordinarily vary, according to the types of blanks, from about 900 deg. to 1,050 deg.

After the information we have been able to collect the tensile strength curve in function of temperature of semi-hard steel would have approximately the form that we have traced in Fig. 10.

The greater the temperature of a blank, the less high will be the power necessary, consequently p will be as much less as the temperature will be increased. As in drawing we act in some form of tension on the section to be displaced, the curves of the value of p in relation to the temperature will be practically analogous to that of Fig. 10.

It would be sufficient to determine exactly the curve of the values of p in relation to the temperature in order that at each instant we could deduce the value of R and the corresponding power.

In order not to remain in a purely theoretical domain, we have considered some well-defined cases.

These values are in the order of 0·9 to 1·1 p average. We have deduced from them zones A, B, C, which give the difference that we can practically allow for p in each of the cases and for the different thicknesses of sides.

In the diagram, Fig. 12, we have traced the curves representing the resistance R to displacement in relation to the thickness of sides of the blanks before drawing.

These values in each of the cases are theoretical, and correspond to drawings taken by means of dies whose connecting radius is equal to 7½ times the diminution of the thickness of the side. They can therefore be considered as the minima.

IV. *Variation of the Strain ϕ and the Elongation.*—If the resistance to displacement R in a given section of die and a determined pass is solely a function of the thickness of sides of the blank or more exactly of the temperature, it is not the same for the strain ϕ sustained by the remaining section.

This strain varies according to the temperature at breakdown. This results from differences in their temperature.

Let us take, for example, a series of identical blanks at different temperatures, which we will draw in such a manner as to give the same elongation in the neighbourhood of the maximum possible.

All these blanks satisfy the condition $\frac{\phi}{R}$ = constant with ϕ in the neighbourhood of the breaking strain.

We have seen that R increases very rapidly with the lowering of temperature; from this it results that for a less hot drawing an increase in the power is necessary, from which often results a slowing down of the speed of the press, especially if the power of the latter is a little too exact.

The slowing down influences very little the temperature of the remaining section, but the zone of contact with the die becomes cooler. R increases very quickly

Fig. 11.

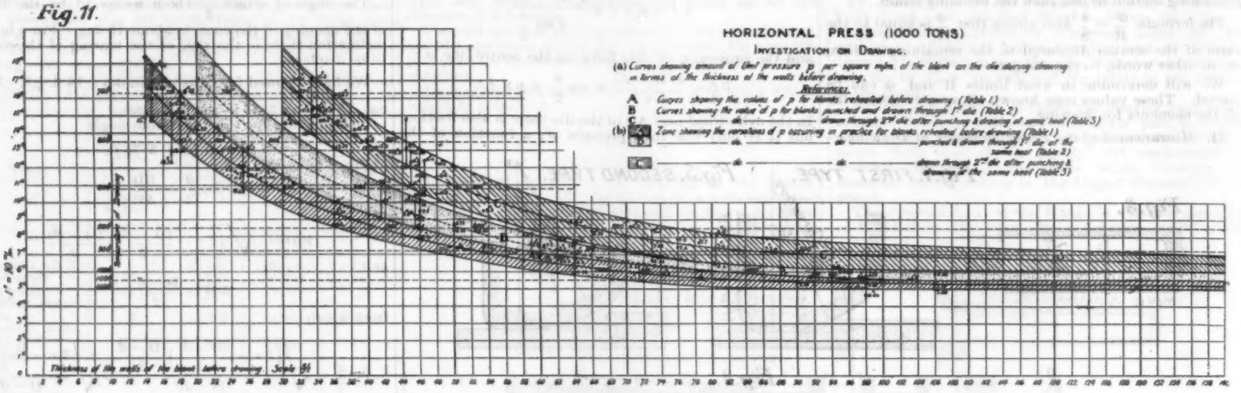
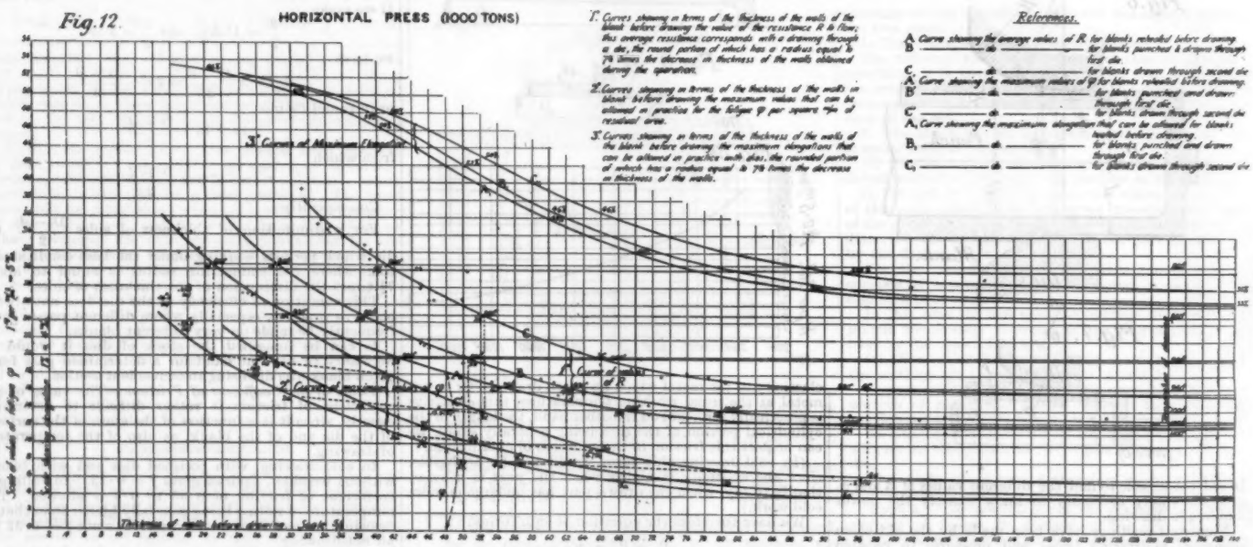

HORIZONTAL PRESS (1000 TONS)
INVESTIGATION ON DRAWING.
(a) Curves showing amount of lateral pressure p per square mm. of the blank on the die during drawing in terms of the thickness of the walls before drawing.
References.
A Curves showing the values of p for blanks reheated before drawing (Table 1).
B Curves showing the value of p for blanks punched and drawn through 1st die (Table 2).
C ——— drawn through 2nd die after punching & drawing at same heat (Table 3).
(b) Zone showing the variations of p occuring in practice for blanks reheated before drawing (Table 1).
——— do. ——— do. ——— punched & drawn through 1st die of the same heat (Table 2).
——— do. ——— do. ——— drawn through 2nd die after punching & drawing at the same heat (Table 3).
Thickness of the walls of the blank before drawing. Scale 5/1

Fig. 12.


HORIZONTAL PRESS (1000 TONS)
1. Curves showing in terms of the thickness of the walls of the blank before drawing the value of the resistance R to flow, this average resistance corresponds with a drawing through a die, the round portion of which has a radius equal to 7½ times the decrease in thickness of the walls obtained during the operation.
2. Curves showing in terms of the thickness of the walls in blank before drawing the maximum values that can be allowed in practice for the fatigue ϕ per square mm. of resultant area.
3. Curves showing in terms of the thickness of the walls of the blank before drawing the maximum elongations that can be allowed in practice with dies, the rounded portion of which has a radius equal to 7½ times the decrease in thickness of the walls.
References.
A Curve showing the average values of R for blanks reheated before drawing.
B ——— do. ——— for blanks punched & drawn through first die.
C ——— do. ——— for blanks drawn through second die.
A' Curve showing the maximum values of ϕ for blanks reheated before drawing.
B' ——— do. ——— for blanks punched and drawn through first die.
C' ——— do. ——— for blanks drawn through second die.
A1 Curve showing the maximum elongation that can be allowed for blanks heated before drawing.
B1 ——— do. ——— for blanks punched and drawn through first die.
C1 ——— do. ——— for blanks drawn through second die.
3. Curve of maximum elongation ϕ
R. Curve of R
Thickness of walls before drawing. Scale 5/1

We have treated more especially the case of large blanks, besides, they are the more interesting, as much on account of the varieties of the examples as for the importance of the works carried out.

For the drawing of these blanks with a horizontal press of 1,000 tons we have considered the three usual working conditions:—

(*a*) Drawing of blanks after reheating of the punched blanks.

(*b*) Drawing of blanks after punching at the same heat.

(*c*) Drawing in the second die at the same heat of blanks punched and drawn in first die.

In the diagram, Fig. 11, we have traced the curves A, B and C, representing the average values of p, for each of the drawing conditions previously mentioned.

They are established in relation to the thickness of the sides of the blanks before drawing.

It is seen that—

1. In each of the cases p increases rapidly as the thickness of side decreases.

2. The difference between the values of p in each case for a given thickness of sides increases as the thickness decreases.

It is certain that for a blank of a given thickness p can vary between the lower and higher limits of the curves, according to the temperature at which it is drawn. To remain within practical limits we have noted in each case the limits of the variations of power registered, which permits us to determine the corresponding values of p. which the operation is made, but it is further a direct function of the elongation realised during the course of operation.

In fact, if we work on the same blanks, having the same dimensions and the same temperature before drawing, it is certain that the more important the pass, the more the strain carried by the remaining section will be increased.

The relation $\phi \times S = R \times s$ gives besides $\phi = \frac{R \times s}{S}$, therefore ϕ increases as $\frac{s}{S}$, that is to say, as the elongation, its variations can therefore be very considerable, from 0 for a zero pass up to the values capable of causing breakdown of the blank.

It is necessary to determine for a given thickness of side what is the maximum value that can be given to ϕ for a blank, in order that it will not break down during the course of operation.

1. *Maximum Values of ϕ.*—We have also indicated in Fig. 12 some maximum values of ϕ for different thicknesses of sides. We have afterwards traced the curve A' a little below the preceding values in such a manner that in taking for a given thickness the strain indicated by the curve, we are certain not to have breakdown.

Note.—It may appear abnormal that several blanks of the same dimensions appearing to be drawn under the same conditions, can in some cases act normally, and in others present either signs of breakdown or complete and the value of ϕ becomes higher than the breaking strain.

This particular case is often met in practice, and it shows that to draw under good conditions it is necessary to have rapid and sufficiently powerful presses in order that the variations met in practice do not greatly influence the speed.

The maximum values of ϕ should appear to be in the neighbourhood of the figures for tensile resistance given above, since we have a tensile effort on the remaining section.

Nevertheless the figures which are given for the curve A' and which result from their manufacturing readings, are higher, especially for the small thicknesses; this is explained, on the one hand, by the fact that the punch cools the interior of the blank, resulting in an increase of the resistance of the metal; on the other hand, the rubbing of the blank on the punch which supports it produces a rubbing which allows it to carry a superior strain to that which it would support if free and submitted to an equal tensile force.

This action of the punch on the blank is naturally much more apparent the thinner the blank.

For very thick blanks the cooling is small and we can allow that the maximum strain ϕ is practically equal to the tensile strength at same temperature.

2. *Maximum Values of Elongation.*—The curve A' is practically parallel to the curve A, consequently the ratio $\frac{\phi}{R}$ (ϕ maximum) increases with the diminution of

side before drawing. In other words, the maximum elongation that can be given to a blank is as much greater as the blank is thinner.

We have traced Fig. 12 in determining $\frac{\phi}{R}$ the curve A'_1 of the corresponding elongations, to the values of R and of ϕ from the curves A and A' (this curve A' refers to blank drawn after reheating).

The increase is very slight for the very thick blanks, where the punch and the time of operation scarcely influence the cooling. With 70 mm. thickness of sides the elongation possible increases more rapidly, afterwards bending and tending towards a limit of 70 per cent. to the small thicknesses.

The elongations stated are not very numerous, which has prevented us determining the curves of the maximum values of ϕ, especially for points as we have done for A'.

To aid us to construct the curves B' and C' we have indicated on the curves A, B, C, the drawing temperatures for intervals of 50 deg. C. (At equal temperature R is constant whichever be the case taken.) We have therefore the points :—

1A	1B	1C for temperature =	800 deg.
2A	2B	2C for temperature =	850 deg.
3A	3B	3C for temperature =	900 deg.
4A	4B	4C for temperature =	950 deg.
5A	5B	for temperature =	1,000 deg.
6A		for temperature =	1,050 deg.

Let us consider the points 1A, 1B, 1C, which correspond to drawings made at 800 deg.

The point 1A corresponds to a blank of 21 mm. in thickness.
The point 1B corresponds to a blank of 28·5 mm. in thickness.
The point 1C corresponds to a blank of 41 mm. in thickness.

Although these three drawings be made at the same temperature, the maximum strain φ that can be carried by each blank is not the same ; the thinner, cooling quicker, can carry a strain greater than the thick blank, which retains its heat better in the remaining section.

We have assumed that the strains 1b and 1c are a little less than the strain 1 as given by curve A'.

In doing the same for the points 2, 3 and 4, and in reducing each time the difference between the strains (that which is normal, since as we arrive in the greater thicknesses the variations due to cooling are more feeble for an initial constant temperature), we have constructed the curves B' and C' and we have deducted from them the curve for the elongation B_1 and C_1.

These two latter curves are similar to the curves $A_1 - B_1$ and almost confuse with A_1 ; only the curve C_1 differs above the two first. It should therefore be corrected in approaching it by others, since the values of ϕ of the curve C' are a little higher than the real ones, as this curve refers to blanks drawn in two dies for which the finishing punch becomes very hot and has less influence on the blank than in the two previous cases.

For reasons that we have just explained we allow as practical curve of the maximum elongations in relation to the thickness of sides of the blanks before drawing, the curve A_1.

The different elements of drawing for the particular case of large blanks are therefore well defined.

Several problems which show the application of the foregoing are dealt with in the paper.

PART III.

Some Practical Considerations.

The curves which are given in Figs. 11 and 12, on page 680, permit the obtaining of what are the best working conditions ; but we do not, however, neglect the practical side, and that is why we have given some observations which may be useful.

1. *Maximum Elongation.*—In a general manner it is better to keep a little below the maximum elongation obtainable. We can avoid the surprises which may be caused by large differences of temperature, and which we will enumerate below.

(*a*) Slowing down of the press can produce breakdown, or, in case of limited power, the blockage of the blank in the die and on the punch.

(*b*) Signs of breakdown in drawing of the blank, giving a diameter often smaller than that allowed for.

(*c*) Staving of bottom of blank due to the retaining of the temperature in this thicker region. This accident is especially to be feared with punches very conical at the end, and in that case it is advisable to keep well below the maximum elongation. To ensure this, the maximum elongation corresponding to the thickest part of the wall should be adopted.

(*d*) Contraction of the mouth of the blank, which is to be feared especially in the case of long and thin blanks, where the section is very cold when it arrives on the die.

(*e*) Erosions and striation of dies, which are principally produced with blanks at a low heat.

2. *Dies.*—These should have, as nearly as possible, the ideal section indicated and should be very smooth and very hard.

Certain kinds of chilled cast-iron with dressed surfaces give good results. The surfaces of blanks must be well cleaned outside and inside before drawing.

The dies must be abundantly lubricated with black grease. It is well to heat them at low temperature before putting in service, and to be sure of their perfect support in the die-carrier.

3. *Punches.*—The punches require every care both as to finish and to quality. The tensile strength should be 65 kg. to 70 kg. per square millimetre, and tool marks or erosions should be avoided, as these greatly diminish their life.

The spraying after each press should be done regularly on all the surface and on the greatest length possible, in such a way as to avoid deformation.

Apply a mixture of tallow and blacklead, or of grease with blacklead, carefully over the punch before drawing, in order to prevent the blank adhering to it, and to facilitate the detachment.

4. *Thick Bottom.*—When the blanks have very thick bottoms it is necessary that the die should have a diameter slightly greater or equal to the external diameter of the bottom.

It often occurs that when a blank is very eccentric it turns to the drawing without the die having touched it ; if it is thick, the torsion is often very important.

5. *Blanks of Internal Diameter Larger than the Punch.*—When a blank has an internal diameter appreciably larger than that of the punch, the roughed blank must be treated very regularly ; if not, the drawing tends to create more elongation in the hot part, which often diminishes the thickness and creates an eccentricity which did not exist before drawing.

6. *Drawing in Several Dies Simultaneously.*—This procedure enables very large total elongations to be obtained. It is to be especially recommended in the case of blanks with very weak sides, and with some quick presses.

The pass must be divided out in such a manner that the work must be greatest at the first die and decrease successively on the others.

This method of operation also allows the stroke of the press to be reduced and diminishes the wear on the last die, which has only light work to carry out.

CATALOGUES.

Switch Gear.—Messrs. Donovan and Co., 47, Cornwall-street, Birmingham, send us a copy of their illustrated catalogue of switch and fuse gear. The catalogue contains 40 pages with clear descriptive text and many priced lists.

Oxy-Acetylene Welding.—An oxy-acetylene, high-pressure welding and cutting system is explained, and all the necessary equipment described and illustrated in a catalogue received from Messrs. Allen-Liversedge, Limited, 106, Victoria-street, London, S.W. 1.

Hand Barrows.—A priced catalogue of metal hand barrows of usual form, and also of special designs for tilting, carrying water, concrete, cinders, carboys, offal, &c., has been received from Mr. H. C. Slingsby, 142, Old-street, London, E.C.

Screwing Tools.—A catalogue of screwing taps and dies and screw gauges has been received from Messrs. Wolseley Motors, Limited, Adderley Park, Birmingham, indicating a complete range of these tools made to fine limits of accuracy and in usual and special forms.

Drafting Machine.—A British-made drawing apparatus is described and illustrated in a catalogue issued by the makers, Messrs. Mavitta Drafting Machines, Limited, Park-road, Aston, Birmingham. The considerable advantages claimed for this design are well worth consideration.

Road-Making.—Some interesting text and illustrations of the making of the new North Circular-road round the north of London, and the machinery and methods used comes from the Walker Weston Company, Limited, 7, Wormwood-street, London, E.C. 2, whose reinforcement is being used in the concrete.

Transmission.—Shafting, pulleys, various bearing supports (including girder and column clips), couplings, belting, lifting pulley blocks, and the general run of shafting accessories, are very well represented in a catalogue received from Messrs. Martin Brothers Machinery, Limited, 33, Bridge-street, Manchester.

Forgings.—A number of very fine examples of hammered and drop-forgings are shown in a catalogue to hand from Messrs. N. Hingley and Sons, Dudley. These include heavy ship's shafting, crankshafts, rotor spindles, a great deal of chain work and chain connections, and many small machine parts. The qualities of the steel are made to conform to the most rigid tests.

Machine Tools.—The new edition of their illustrated catalogue of machine tools which has been issued by Messrs. Pollock and Macnab, Limited, Bredbury, Stockport, covers a very wide range of requirements. In addition to all the usual machine-shop equipment it includes particulars of some machines for boiler and structural work, and some of the manufacturing type.

Starters and Switch Gear.—A number of leaf catalogues referring separately to direct-current panels for motors up to 5 h.p., machine tool controllers, alternating current ironclad switch gear up to 30 h.p., starters for squirrel-cage motors, slow-motion rotor starters, and direct-current automatic motor starters up to 250 h.p. have been received from the Electrical Apparatus Company, Limited, South Lambeth-road, London, S.W. 8.

Open-Hearth Furnace Chargers.—The Wellman Smith Owen Engineering Corporation, Limited, Darlaston, send a very handsome book describing their extensive works and also a catalogue dealing with machines for charging open-hearth steel furnaces. Quite a variety of these machines is necessary to meet the numerous methods and conditions of working. Steel-makers, both at home and abroad, will find these catalogues of exceptional interest.

Compressors.—Machinery and fittings for the compression of air or gas to high or low pressures are dealt with in a handsome and exhaustive new edition of their compressor catalogue recently issued by Messrs. Peter Brotherhood, Limited, Peterborough. The various types of machines, and their principal parts are well illustrated and fully described, and some excellent tables of capacities are included. The plant dealt with covers a very wide range of requirements.

Colliery Lamp.—An electric lamp for the roadways and shafts in mines is described in a catalogue issued by the Thor Electric Safety Lamp Company, Limited, Rea-street South, Birmingham. It is self-contained, with four cells in series—the cells being the same as are used for the miners' handlamps. It is approved by the Mines Department, and the selling agents are Messrs. Haslam and Stretton, Limited, 11, Windsor-place, Cardiff, as well as others in the various mining centres.

Tar-Macadam Machinery.—To make tar-macadam aggregate durable it is, of course, necessary to dry and heat the material preparatory to treating it with tar. The Ransome Machinery Company, Limited, 14, Grosvenor Gardens, London, S.W. 1, send us a catalogue explaining the method of manufacture and illustrating the machinery for carrying out the work in all its stages on the road. This catalogue will be of much practical interest to the engineers of local authorities and road contractors.

Electric Lifts.—The entire installation and control systems for passenger lifts and medium and heavy goods lifts, are described in a special catalogue received from Messrs. S. H. Heywood and Co., Limited, Reddish, near Stockport. The control systems and safety devices receive very careful attention in these designs—to such a degree that it seems almost impossible to mismanage a lift. The range of work described in the catalogue includes all types of passenger lifts, goods lifts, special lifts for carrying metal and fuel to the top of cupolas, and railway wagon lifts of which two excellent examples are shown, each capable of lifting up to 30 tons.

Mining Machinery.—A catalogue, comprising about 20 booklets and leaflets enclosed in a leather case, and mainly relating to mining machinery, comes from Messrs. Head, Wrightson and Co., Limited, Stockton-on-Tees. Pit-head gears, cages, screening, washing and sorting plant for coals, are dealt with, and among ore-milling machinery is included a very wide range of crushers, grinders and stamps, and also a rod mill in which loose steel rods enclosed in a cylinder are used in much the same way as in a ball mill. Ore roasting furnaces, cement-making plant, agitators, steel wagons, pulley blocks and iron castings, including heavy castings and sewer and tube-railway construction parts, each have a separate publication devoted to them. The catalogue, as a whole, is a very creditable production, and should be of special interest to export agents and mining engineers in connection with Colonial and foreign business.

Reduction Gears : Erratum.—With reference to our notice of a catalogue of reduction gears appearing on page 331 of our issue of August 26 last, Messrs. Joseph Baker, Sons and Perkins, Limited, Kingsway House, Kingsway, London, W.C.2, inform us that the number of standard and other sizes there mentioned was incorrectly stated. They actually make 15 single gears and 35 standard and non-standard double gears with ratios ranging from 4 : 1 to 411·6 : 1. They also add that, although 65 h.p. is the largest power specified in the catalogue, their size 4 P.D. will transmit 160 h.p. at 50 r.p.m.

Synthetic Acetic Acid.—The manufacture of synthetic acetic acid interests metallurgists because the main raw material, calcium carbide, is a product of electric furnaces which may also serve for the manufacture of alloys. During the war the Canadian Electro-Products Company, of Shawinigan Falls, is said to have produced nearly 20,000 tons of glacial acetic acid per year ; the works seem to be the biggest concern of this kind. Technical information about the processes used there and elsewhere is given in the Journal of the Society of Chemical Industry of September 30. The generation of acetylene from calcium carbide by the aid of water may be continuous or discontinuous ; the former method requires more water than the latter and is less economical, because acetylene is soluble in water and cannot profitably be recovered from that solution. Of the gaseous impurities of acetylene the gaseous compounds of hydrogen with arsenic and phosphorus are the most dangerous and troublesome ; they are removed with the help of oxidising agents. The acetylene has to be hydrolysed into acetaldehyde, and this is still done, as proposed years ago by Lagermark, Eltekow and others, by passing the acetylene through sulphuric acid containing a catalyst which at present is generally mercuric sulphate. The acetaldehyde produced is condensed in brine-cooled condensers ; the reaction is simple, but the catalyst loses its activity and is, in Canada, regenerated by electrolysis. The yield is improved by adding ferric sulphate and some pyrolusite (manganese dioxide) to the original mixture of sulphuric acid and mercuric oxide ; the processes of Meister Lucius and Brüning, of Dreyfus (British Cellulose Company) and of the Canadian Company and others differ in the details. The acetaldehyde is finally oxidised to acetic acid in aluminium-lined kettles into which air is forced, manganese acetate being the usual catalyst added ; the reaction evolves heat, and the liquid has to be cooled ; though the gas pressure is kept at 5 atmospheres, considerable quantities of aldehyde escape together with the nitrogen of the air and have to be recovered in scrubbers. The whole manufacture of synthetic acetic acid is not expensive ; yet with calcium carbide at 30*l.* per ton, which was the price in this country last June, the acid would cost about 73*l.* per ton, which is more than the cost of glacial acid made by the distillation of wood. The present conditions are, therefore, not favourable to the manufacture of synthetic acetic acid over here, and wood distillation is generally likely to be pushed.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

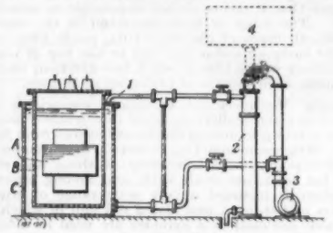
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

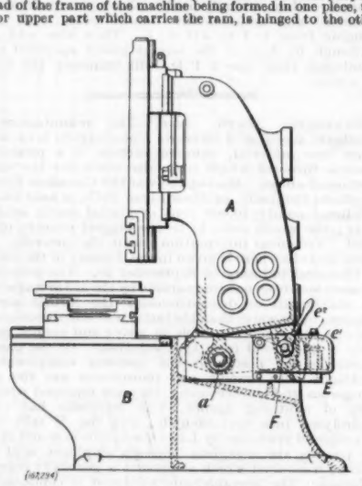
167,197. H. A. Carney, Mobberley, and H. M. Lacey, Paddington, London. Cooling Transformers. (2 *Figs.*) April 22, 1920.—According to the invention, the transformer, which is immersed in oil in known manner in a suitable container, is maintained at a low temperature by the evaporation of water which has no direct contact with the oil, and which is not merely circulated as in other known arrangements. The vapour arising



from the water is led as it is formed into a condenser, and is preferably drawn off at a partial vacuum. A is the transformer placed in a tank B containing oil. Water nearly fills the surrounding casing C, the vapour arising from the water being led through a pipe 1 to a condenser 2, where it is liquefied by water forced into the condenser by a pump 3 or admitted from a tank 4. (*Accepted August* 17, 1921.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

167,294. H. Butler, Halifax, H. Butler, Halifax, R. H. Hayhurst, Halifax, and W. Alderson, Halifax. Slotting or Vertical Shaping Machines. (3 *Figs.*) May 6, 1920.—Slotting machines, or vertical shaping machines, according to this invention, have means whereby work may be machined either at right angles to the table, or at an angle greater or less than 90 deg. at either side of the perpendicular. For this purpose, instead of the frame of the machine being formed in one piece, the one or upper part which carries the ram, is hinged to the other



or lower part which carries the work-table. The upper part A is hinged to the lower part B at *a*, and is accurately fitted into such part. The upper part is capable of being turned to either side of the perpendicular, say, for example, through a distance of 10 deg. This is effected by a worm E in a bracket *e*1 attached to the lower part B and gearing with a toothed segment *e*2 attached to the upper part A. When the upper part has been adjusted to the required angle, it is securely locked to the lower part by draw bolt F. (*Accepted August* 17, 1921.)

167,401. A. H. Lloyd, Earlsdon, Coventry. Reamers. (2 *Figs.*) September 4, 1920.—According to this invention, the blades B, which are guided radially in slots A^3 in the reamer body A, are adapted to float, and also to be collapsed therein, and for this purpose their inner ends rest upon the end of a flexible floating rod or mandrel C located within the axial hole A^4 in the body A. The rod C, constituting the mandrel, is movable both lengthwise and angularly of its axis, and is rounded in an axial direction of the rod at the part C^2 opposite the ends of the slots A^3, so that lengthwise of the rod its contour there is spheroidal, or preferably resembles that of a barrel. This rod is flexible near the rounded end. For example, it has one or more joints C^3 adapted to give flexibility in all directions necessary for flotation of the blades, and the part of the rod between the joints and the rounded end C^2 has a clearance in the axial hole A^4. This end C^2 thus can vary its position slightly in any direction radially of the body. Upon the rounded end C^2 the inner bevelled ends of the blades B rest, and as this end is rounded there is only a point contact between each blade and the end of the mandrel. The rounded end of the rod therefore determines the size of the cutting circle of the blades, but as it can float slightly in radial

Fig. 1.

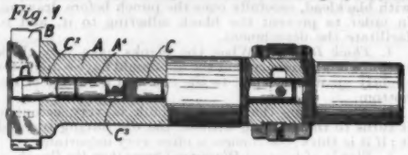


Fig. 2.

directions in the reamer body, this cutting circle can be slightly eccentric to the axis of the body, but it will be clear that the end of the rod will centre itself in the work, which is the chief feature of the invention. (*Accepted August* 17, 1921.)

167,412. H. Holloway, Sparkbrook, Birmingham. Ball Bearings. (3 *Figs.*) November 5, 1920.—The invention essentially consists in grinding the bearing faces of one or both of the race rings at dissimilar angles. The inner race ring *a* is in one piece, and an angular groove around its periphery forms a track *b*. The track is formed of two flat surfaces *c* and *d*

Fig. 1. Fig. 2. Fig. 3.

converging to the axis of the bearing. The balls *e* are retained in the groove by a second ring which is divided circumferentially into two parts *f*, *g*. The inner faces of the parts *f*, *g* are ground at an angle, and when placed against each other they form a track of cross-section substantially similar to that of the inner ring. (*Accepted August* 17, 1921.)

166,709. The Hon. Sir Charles Algernon Parsons, Newcastle-on-Tyne, S. S. Cook, Newcastle-on-Tyne, and L. M. Douglas, Newcastle-on-Tyne. Thrust Bearings. (4 *Figs.*) April 21, 1920.—In thrust bearings in which the thrust is taken by pads or blocks pivotally mounted on a carrying member, the pivoted pads, and in some cases also the members adjacent to the pads, are made of a material which does not vary in dimensions with variations of temperature or of a material having an extremely small positive or negative co-efficient of thermal expansion. The collar A of the shaft B is retained between two sets of pads C, each of which is faced with bearing metal let into undercut grooves, and provided on its rear face with a projection F having a convex face of slight curvature. The carrying member G is provided with a number of radial slots H

Fig. 1.

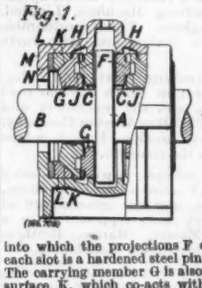
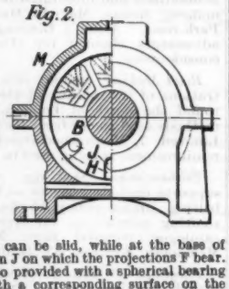


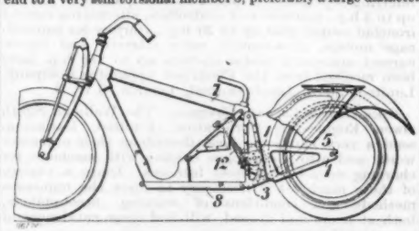
Fig. 2.



into which the projections F can be slid, while at the base of each slot is a hardened steel pin J on which the projections F bear. The carrying member G is also provided with a spherical bearing surface K, which co-acts with a corresponding surface on the seat L, while finally between the seat L and the walls M of the casing, a liner N is inserted for adjustment purposes. The pads C, in accordance with the invention, are made of a material such as "invar" steel, the dimensions of which vary only to a very slight extent with variations of temperature. It may, in some cases, be necessary to make the shaft collar A and the members G, L and N, which carry the pads C and transmit their thrust to the casing, of a similar non-expanding material, but, in general, the pads only, or the pads and their pivot pins, are made of the material mentioned. (*Sealed.*)

MOTOR ROAD VEHICLES.

167,245. A. E. Hagg, Hendon, London. Spring Frames. (4 *Figs.*) April 30, 1920.—According to this invention, the spring frame consists of a pair of rigid side members 1 constructed of stiff side plates or pressings which are securely fastened at one end to a very stiff torsional member 3, preferably a large diameter



steel tube, whilst the axle 5 for the rear wheel is attached to the other end. The main frame 7, 8 is provided with bearings of ample dimensions about which the torsional member 3 can rock. The side members or torsional member are also provided with an anchorage adapted to receive a shock-absorbing spring 12. With this arrangement the rear wheel can move up and down against the action of the spring 12 and road shocks are not transmitted directly to the driver or passenger. (*Accepted August* 17, 1921.)

166,939. B. S. A. Cycles, Limited, Small Heath, Birmingham, and R. H. Pearsall, Small Heath, Birmingham. Spring Drives. (7 *Figs.*) April 16, 1920.—To overcome the difficulties and disadvantages due to the use of long or short springs to take up variation in engine torque, two or more springs 11, circumferentially disposed in series, are arranged between

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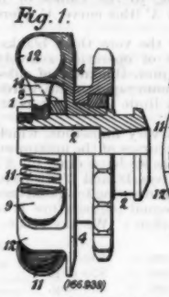
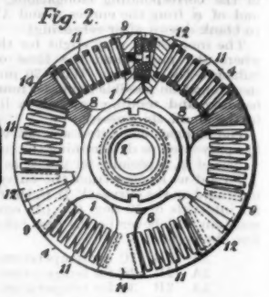


Fig. 2.



arms 9, 12 on the driving and driven members 1, 4, respectively, with their adjacent ends engaging an idler member 14. The idler member consists of a central boss 8 mounted freely on the spindle 2 and having radial arms 14 which are interposed between the arms 9, 12 on the driving and driven members 1, 4, respectively, and against which the springs abut. (*Sealed.*)

166,827. A. Citroen, Paris, France. Springs. (2 *Figs.*) August 4, 1920.—For preventing accidents in case of fracture of the main leaf of the laminated or leaf springs of motor road vehicles, a spring leaf 6 is placed directly in contact with the main leaf 4 of the spring throughout the whole of its length, and slides freely in the member connecting the main leaf to the axle.

Fig. 1.

Fig. 2.

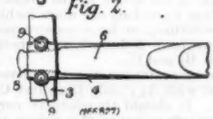
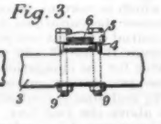


Fig. 3.



The main leaf 4 secured to the axle 3 by a flange 5 which firmly grips its edges and which is cut to accommodate the free end of the second leaf 6, which projects beyond the axle. The leaf 6 has projections 8 which prevent it from escaping from the flange 5. The bolts 9 secure the flange 5 to the axle 3. (*Sealed.*)

166,752. W. J. Young, Loughborough. Motor Road Vehicles. (8 *Figs.*) May 4, 1920.—The movable road wheel 2 of a motor road vehicle is mounted to turn on a vertical axis bearing situated within the hub of the wheel, the bearing having combined therewith resilient shock-absorbing means. The hub 1 of the wheel 2 is mounted on the outside of an annular case 5 which, in turn, is mounted on the opposite ends of a central vertically disposed tubular housing 8, slidable within a bearing 9 on a cross bar 10 fastened to the ends 11 of the chassis frame 12. Passing transversely through the bearing 9 and through longitudinal slots 13 in the housing 8, is a pin 14 which carries a block 15 having a shoulder against which a coil compression

Fig. 1.

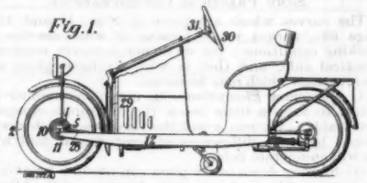
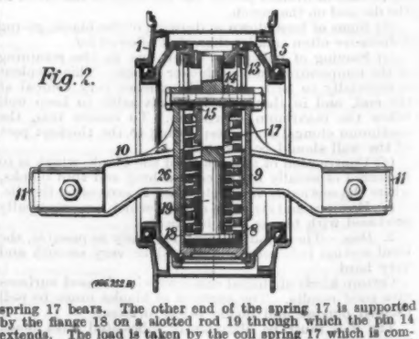


Fig. 2.



spring 17 bears. The other end of the spring 17 is supported by the flange 18 on a slotted rod 19 through which the pin 14 extends. The load is taken by the coil spring 17 which is compressed between the flange 18 and the block 15 during upward movement of the housing through the bearing 9 or during downward movement of the bearing in the housing. To assist the main coil spring 17, a supplementary coil compression spring 26 is arranged within the main spring. The turning movements of the wheel on the steering pivot constituted by the housing 8 are effected and controlled by steering mechanism comprising a fork 28 attached to the case 5, and a lever connection 29 operable by a toothed gear, which in turn is actuated by a wheel 30 and rotary shaft 31. (*Sealed.*)